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# The Culicoides of New Mexico (Diptera: Ceratopogonidae)[1]

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## ABSTRACT

A taxonomic review is provided for the biting midges of the genus *Culicoides* (Diptera: Ceratopogonidae) occurring in New Mexico. The descriptions of females and males, if known, of 23 species are given of which 4, *Culicoides (Drymodesmyia) byersi, C. (Oecacta) doeringae, C. (O.) novamexicanus* and *C. (O.) sublettei* are described as new to science. *Culicoides pampoikilus* Macfie, previously reported from Central America, is recorded from New Mexico and constitutes a new United States record. Biological as well as morphological evidence is presented to support the relegation of *C. variipennis australis* Wirth and Jones to synonomy. *Culicoides tenuilobus* Wirth and Blanton is elevated from synonomy.

## INTRODUCTION

The genus *Culicoides*, an almost worldwide group of minute hematophagous gnats, is a conspicuous part of most environments. The anthropophilic behavior of these flies makes them readily perceivable to even the most unobserving "naturalist."

It has only been in the last 40 years or so that students of the Ceratopogonidae have devoted their energies to the taxonomy of these small flies. The Palearctic fauna has been well studied through the efforts of the following workers: Goetghebuer (1920, 1933-1934) first monographed the Belgian species and later more extensively studied the Palearctic fauna, while Kieffer (1925) and Edwards (1926, 1939) treated the French and British species. Such workers as Callot and Kremer are continuing the studies of the French fauna, while Kettle and Lawson are among the more recent contributors of the studies relating to the British species. The revision by Campbell and Pelham-Clinton (1960) represents the most up-to-date treatment of the British fauna. Among the more notable Russian contributors to the taxonomy of the Palearctic *Culicoides* have been Gutsevich and Dzhafarov.

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Carter, Ingram and Macfie (1920), DeMeillon (1936-1961) and Fiedler (1951) have contributed to our knowledge of *Culicoides* in the Ethiopian Region, although Macfie's later contributions were by no means restricted to this area.

The Australian species have been recently monographed by Lee and Reye (1953). The Oriental Region has long been ignored by ceratopogonid workers and, with the exception of a reference by Causey (1938) to species occurring in Siam, little is known of the *Culicoides* of this region. Tokunaga (1932 to date) and Arnaud (1956) have conducted extensive taxonomic studies on the species in Japan and surrounding areas, and, in addition, Tokunaga has recently presented excellent studies of the Micronesian and Papuan fauna.

Valuable contributions have been made to the taxonomy of the Neotropical species by Barbosa (1943-1952), Fox (1942-1955), Lane (1944-1961), Lutz (1912-1914), Macfie (1937-1948), Ortiz (1949-1954), and Vargas (1944-1960). The excellent monograph of the Panamanian species by Wirth and Blanton (1959) provides a valuable addition to our knowledge of the Neotropical species.

Within the boundaries of the continental United States the *Culicoides* of California, Florida, Wisconsin, Oklahoma and New York have recently been the subjects of rather extensive taxonomic studies. A perusal of the literature pertaining to the *Culicoides* of the United States, however, reveals a conspicuous void regarding the culicoid fauna of the southwestern states.

Information regarding the *Culicoides* of the southwestern United States can be found in the works of James (1941, northern Colorado), Fox (1946, Utah), Wirth (1952, California), and Khalaf (1952, 1957, Oklahoma), and Wirth (1955), Wirth and Bottimer (1956), and Jones and Wirth (1958) have studied the Texas species. Occasional records of southwestern species are given by Foote and Pratt (1954) in their treatment of the *Culicoides* of the eastern United States. Wirth and Hubert's (1960) study of the *copiosus* group of *Culicoides* includes distribution records for species occurring in California, Arizona and Texas, as well as some Mexican records.

*The Catalog of North American Diptera, North of Mexico* (1965) lists 21 species occurring in Texas, and Khalaf (1957) lists 22 valid species in Oklahoma. This compares quite unfavorably with 9 species recorded in the literature as occurring in New Mexico. New Mexico, the point of fusion of four physiographic regions, i.e., Southern Rocky Mountains, Great Plains Province, Colorado Plateau and the Basin and Range Province (Fenneman, 1931), presents a diverse ecological situation. Because of this diversity, one would expect a varied and interesting fauna of *Culicoides*.

The primary objective of this study is the presentation of a taxonomic treatment of the *Culicoides* of New Mexico. It is hoped that this endeavor, when added to the works of Wirth (1952) and Khalaf (1957), will form the basis for a future extensive taxonomic investigation of the *Culicoides* of the western United States. Such a study is of paramount importance if serious investigations involving the public health significance of this group in the western United States are to be continued.

## ACKNOWLEDGMENTS

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Special appreciation is given to the American Museum of Natural History for their financial assistance from the Theodore Roosevelt Memorial Fund.

In conclusion, I would like to express my deep obligation to my wife, Wilinda, for her encouragement and assistance throughout the duration of this study.

## HISTORICAL REVIEW

One of the first accounts of *Culicoides* was given as early as 1713 by Derham (Edwards, 1939) in his excellent description of a small gnat referred to as *Culex minimus nigricans maculatus sanguisuga.* Concerning this small gnat, Derham states, "It is spotted with blackish spots, especially on the wings, which extend a little beyond the body. It comes from a little slender Eel-like Worm, of a dirty white Colour, swimming in stagnating Waters by a wrigling Motion.

"Its *Aurelia* (pupa) is small, with a black Head, little short Horns, a spotted, slender rough Belly. It lies quietly on the top of the Water, now and then gently wagging itself this way, and that.

These Gnats are Greedy Blood-suckers, and very troublesome where numerous . . . ."

In spite of this early beginning the Ceratopogonidae were shunned by early workers because of their small size and the consequent difficulties imposed by their taxonomy. Only one species of *Culicoides,* then called *Culex pilicarius,* was known to Linneaus. Winnertz's (1852) monograph of the European species represented the first major attempt at the classification of the Ceratopogonidae. Both Winnertz and Coquillett, who first studied the North American fauna, included all the known species in the genus *Ceratopogon.*

It was Kieffer who first began to define generic limits in the Ceratopogonidae and in 1906 resurrected the generic name *Culicoides* Latreille (1809). Following the work of Kieffer, Malloch (1917) proposed the recognition of the Ceratopogonidae as a distinct family from the Chironomidae.

Hoffman (1925) reviewed the North American species of *Culicoides,* described several new species and included a key for females. The 1937 revision of the North American *Culicoides* by Root and Hoffman included additional new species and distribution records, keys for female characters and male genitalia and illustrations of male genitalia of most of the known species.

With the exception of a few isolated descriptions of new species or species lists of very limited geographical areas, the next taxonomic works were those of Johannsen (1943, 1952) and Wirth (1952). Johannsen's (1943) generic synopsis and list of the North American species of Ceratopogonidae filled a long neglected taxonomic gap. The monograph on the Ceratopogonidae (=Heleidae) of California by Wirth (1952), with its excellent species descriptions, keys and overall systematics, stands as the outstanding North American treatment of this family.

Foote and Pratt (1954) treated the species occurring in the eastern United States; however, the usefulness of this paper is somewhat limited, due to the inadequacy of the species descriptions. These authors were among the first to attempt classification of females on the basis of structural characters, instead of relying completely on the traditional wing and mesonotal patterns.

Khalaf (1952, 1957), studying the seasonal incidence of the *Culicoides* of Oklahoma, described the relative abundance and distribution of these flies and provided descriptions of new species and keys to the Oklahoma *Culicoides*. As in the case of Foote and Pratt, Khalaf supplemented his 1957 key to external characters and male genitalia with a key to slide-mounted females. This is of significance to the problem at hand, since many of the species found in Oklahoma also occur in New Mexico.

The catalogue of the bloodsucking midges of the Americas by Fox (1955) includes a compilation of the known species, together with keys and a geographical index; however, more up-to-date information regarding distribution records, classification and synonymies is now available in the Catalog of North American Diptera (Stone *et al.*, 1965).

Considerable emphasis has recently been placed on the taxonomy of species groups, resulting in revisions of the *copiosus* group by Wirth and Hubert (1960), the eastern species of the *piliferus* group by Wirth and Hubert (1962), and the *obsoletus* group of eastern U.S. by Jamnback and Wirth (1960). Although these studies represent a strong beginning, there exists a great need for studies involving the western species of the *piliferus* and *obsoletus* groups, as well as the *crepuscularis* group, or the subgenus *Selfia,* to name only a few pressing taxonomic problems.

The study of the immature stages of *Culicoides* in the United States has recently been given a needed stimulus through studies by Jones and Williams, although our knowledge still lags behind that of the British, who have amassed considerable literature relating to immature stages of various Palearctic species through the excellent works of such entomologists as Kettle, Lawson and Parker.

## ECONOMIC IMPORTANCE

The bloodsucking behavior of *Culicoides* (and two related genera of Ceratopogonidae) has gained them considerable notoriety. When these small gnats (commonly known as punkies, moose-flies, no-see-ums or sand-flies, although the last name has been applied also to *Phlebotomus*) occur in large numbers, their hematophagous habits result in great annoyance both to man and his animals. To many people the mention of "biting gnats" brings to mind painful, vicious, invisible and insatiable bloodsuckers. As Reye (1964) has so ably stated, "the abrupt fall in morale and the strong desire to be elsewhere which they (*Culicoides*) engender, are difficult to convey to those who have not experienced them." The irritation resulting from the bites of these small flies has been described as worse than that of mosquitoes, and the reaction by some people to the saliva of *Culicoides* may be quite severe. Their small size enables them to pass through netting or screens which would normally restrain a mosquito. Several authors have cited evidence of depressed development and property value in coastal and resort areas where high infestations of these gnats occur. In some areas outdoor work is made impossible due to the severity of attack of *Culicoides*. It was probably these conditions which prompted Kettle (1962) to comment that while "one midge is an entomological curiosity, a thousand can be hell!"

It was Sharp (1928) who made the first definite association between pathogen transmission and *Culicoides* when he reported the development of the microfilariae *Acanthocheilonema perstans* in *Culicoides austeni* and *C. grahami* in Cameroon, West Africa. This was later confirmed by Hopkins and Nicholas (1952); however, Henrard and Peel (1949) and Chardome and Peel (1949) doubted the validity of Sharp's conclusions when they demonstrated *C. grahami* to be an intermediate host of *Dipetalonema streptocerca* in the Belgian Congo. Duke (1954) confirmed the earlier experiments on the development of *D. streptocerca* in wild *C. grahami* but, in addition, showed the flies will take up, at the same time, fully representative numbers of *A. perstans* microfilariae when the host is infected with both parasites.

Steward (1933) demonstrated the transmission of *Onchocerca reticulata* (as *O. cervicalis*), the principle causitive agent of fistulous withers in horses, by *C. nubeculosus* in England. This was followed by a report by Dampf (1936) of the development of *O. cervicalis* and *O. volvulus* in *Culicoides* in Mexico; however, later experimentation by Gibson and Ascoli (1952) failed to show *Culicoides* as a vector of *O. volvulus*. Buckley (1938) has shown *Onchocerca gibsoni*, occurring in cattle in Malaya, to be transmitted by the bite of *Culicoides*.

*Culicoides* was demonstrated by Buckley (1934) to be an intermediate host of *Mansonella ozzardi*, a common human filarial blood parasite in the British West Indies. Robinson (1961) reported the early development of an avian filarial worm in *C. crepuscularis*, which had fed on an infected starling. Allergic dermatitis, Queensland itch, of horses in Australia has been shown by Riek (1954) to be caused by hypersensitivity to bites of *Culicoides brevitarsis*.

More recently Fallis and Wood (1957) have established that *Culicoides downesi* is an intermediate host of the protozoan *Haemoproteus nettionis* occurring in ducks in Canada, and Fallis and Bennett (1960) have demonstrated sporogony of *H. canachites* in *Culicoides sphagnumensis*. Akiba (1960) has incriminated *C. arakawae* in the transmission of *Leucocytozoon caulleryi* to chickens in Japan, and Garnham et al. (1961) have shown *Culicoides* to be involved in the transmission of *Hepatocystis kochi* in monkeys in Africa.

The transmission of fowlpox virus by *Culicoides* has been suggested by Tokunaga (1937), and bluetongue virus has been shown to be transmitted to sheep by the bite of *Culicoides* by du Toit (1944), Price and Hardy (1954) and Foster, Jones and McCrary (1963). The virus of eastern encephalitis has been isolated from an unknown species in *Culicoides* in southern Georgia by Karstad *et al.* (1957). Levi-Castillo has described the isolation of Venezuelan encephalitis from *Culicoides* in Ecuador (cf. Karstad *et al.* 1957).

The beneficial aspect of ceratopogonids has been greatly overshadowed by their bloodsucking habits. Recent authors (Macfie, 1944; Posnette, 1944; Warmke, 1951, 1952; Saunders, 1959; Wirth, 1956) have shown ceratopogonids to be involved in the pollination of cacao and para rubber trees in tropical America. Wirth (1956) has shown that two species of culicoid flies, *C. jamaicensis* and *C. diabolicus,* are involved in rubber tree pollination in Brazil and Guatemala.

As of this time there have been no published reports involving the economic significance of this group in New Mexico. I have accumulated definite man-biting records for two species, *C. reevesi* Wirth and *C. obsoletus* (Meigen), and have taken engorged females of *C. stellifer* (Coquillett) on two occasions from light traps located in horse and cattle pens. H. T. Miller, Vector Control Section of the New Mexico Department of Public Health, informs me that *Culicoides* constitute a considerable annoyance in the lower Rio Grande Valley of southern New Mexico.

## METHODS AND MATERIALS

Most of the material used in this study was collected at light, either by New Jersey light traps, or by illuminating a white, vertically oriented bedsheet with a 15-watt fluorescent tube. The remainder was obtained by sweep-net collection and rearing of immature stages. Some discussion of the relative merits of the two methods of collection at light might be worthwhile.

By operating the 15-watt light tube from the battery of a vehicle, the collector is relatively mobile and may sample isolated areas where collection with a standard light trap is impossible. The collector is also able to discriminate in his collecting, i.e., he can aspirate relatively pure samples of small flies from the sheet, thus excluding the beetles, moths, etc., common in collections made by light trap, which may damage ceratopogonids. One limitation in the use of the light tube is the endurance of the collector.

It was discovered that the collecting of gnats from the sheet by aspiration could be supplemented by sweeping with a fine mesh insect net at various levels over the light tube. Examination of segregated catches made at the same locality, for example, on the Jemez River, Sandoval County, showed that only one species, *Culicoides hieroglyphicus* Malloch, was collected by aspiration from the sheet; however, by sweeping at various levels over the light tube, small numbers of *C. crepuscularis* Malloch, *C. haematopotus* Malloch, *C. palmerae* James, *C. sitiens* Wirth and Hubert, *C. variipennis sonorensis* Wirth and Jones and *C.* n. sp. nr. *villosipennis* were obtained.

After collection the material was stored in 70% ethyl alcohol. For study purposes alcoholic material is greatly preferred over pinned specimens. The loss of the color pattern of the mesonotal disc is over-compensated by the clarity of structures and the ease with which alcoholic material can be manipulated. Dried specimens are very difficult to handle due to their extreme fragility, and palps, antennae and legs are easily broken and lost during handling. With many of the more common species, identification can often be made on the basis of an alcoholic specimen, thereby alleviating the laborious task of slide mounting the specimen. Large numbers of alcoholic specimens can be stored in a small amount of space as compared to the amount of space required for a similar number of pinned specimens. Jones (1955) states that 4,000 specimens of a medium sized species will only half fill a vial measuring 21 x 70 mm.

In spite of the advent of the so-called "biological species concept," the criteria for specific and subspecific categories are ordinarily still morphological. Since the morphological discontinuities between individuals or groups of individuals must be analyzed and interpreted by the taxonomist, taxonomic procedures have been made more and more complex and sophisticated in order to reduce the amount of subjective interpretation.

It has become increasingly apparent in recent taxonomic works involving the genus *Culicoides* that the traditional approach of using wing and mesonotal disc patterns to differentiate species is no longer sufficient. Refined taxonomic methods have shown that many of what were considered for many years to be species are actually species complexes. Pointed specimens, therefore, although they show mesonotal disc patterns, etc., are of considerably less taxonomic value than dissected slide-mounted specimens. Many important taxonomic characters, e.g., antennal sensoria, mandibular teeth, spermathecal structure, are at best not easily discernible on pointed specimens but are readily observable on dissected specimens.

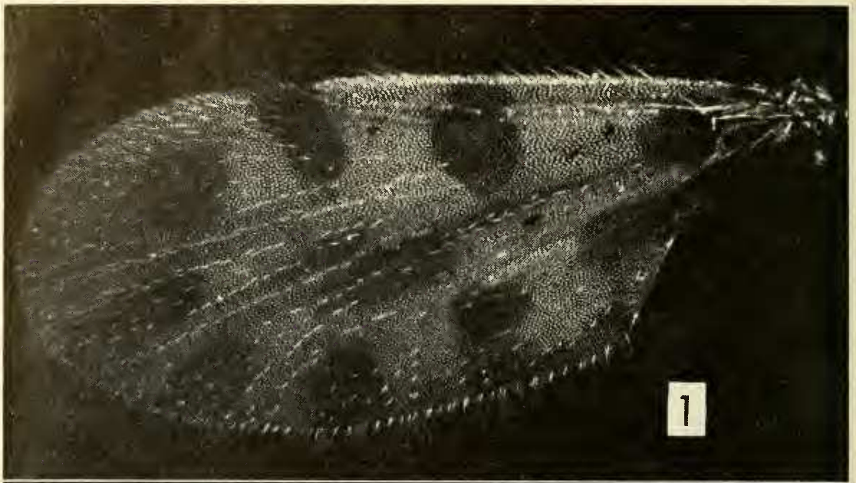
There are several good methods currently in use for slide mounting ceratopogonids. The technique employed in this study was to clear the specimens in 10% potassium hydroxide. The specimen to be mounted was first transferred from 70% alcohol to 95 or 100% alcohol, where one wing was dissected away and mounted under a separate cover glass, using Diaphane, a synethetic resinous medium. The wing can be removed in 70% alcohol and passed through 95 or 100% alcohol and then mounted; however, on several occasions when attempts were made to transfer the wing to the higher gradient of alcohol, it became torn or otherwise damaged.

After the wing was removed, the specimen was placed in 10% potassium hydroxide for clearing. I found chemical spot plates useful for clearing specimens. The specimen was retained in the KOH solution, which may be heated or used cold, until the proper degree of clearing had been achieved. The amount of time needed to clear a specimen properly depends on the amount of sclerotization, as well as size, and can only be learned through experience. Next, the specimen was washed in distilled water to which a drop of 10% glacial acetic acid had been added to stop the macerating process. After washing, the specimen was dehydrated in absolute alcohol and transferred to a drop of mounting medium on the slide, where the head and abdomen (or genitalia, if the individual is a male) were dissected away from the thorax under a wide field microscope. On the slide, the head was oriented dorsal surface up, the antennae and palps arranged and the mouthparts manipulated in such a fashion as to make the mandibular teeth visible. Special attention must be given to mounting the head and genitalia in order that they present a good symmetrical view. The coverglass was then applied, the slide labeled and then put away, preferably in an oven, to dry.

The use of Diaphane instead of balsam is advantageous, since it does not become tacky during arrangement of the dissected parts of the fly on the slide and permits mounting of the wing directly from alcohol.

A second technique for mounting ceratopogonids, preferred by Dr. Willis Wirth, is the phenol-balsam method. Specimens are placed overnight in a warm saturated solution of liquid phenol, prepared by mixing phenol crystals in absolute alcohol. They are then transferred to a solution containing equal parts Canada balsam and liquid phenol and, after standing a few minutes, are transferred to the slide for dissection. Small pieces of broken coverglass are added to prevent excessive flattening by the coverslip. The slides are then oven dried, and pure balsam is occasionally added to replace evaporating phenol. This method allows the preparation of large numbers of specimens at one time.

Many times, when attempting to observe the pattern of pale spots on the wings of *Culicoides,* one is handicapped by the lack of contrast between the pale spots and the remainder of the wing. I have found it very useful to observe the wing pattern by a false dark field illumination of a phase contrast microscope. This is accomplished by turning the phase condenser one or two stops too far while the low power objective is in position. With this false dark field microscopy the pale spots, which are due to the scarcity or absence of microtrichia, appear distinctly dark against a white background and are easily delimited (Figs. 1, 2). Even very small or indistinct spots are evident when viewed under these conditions. This technique, when supplemented by bright field illumination for studying the color pattern, presents an excellent method for examining *Culicoides* wings.



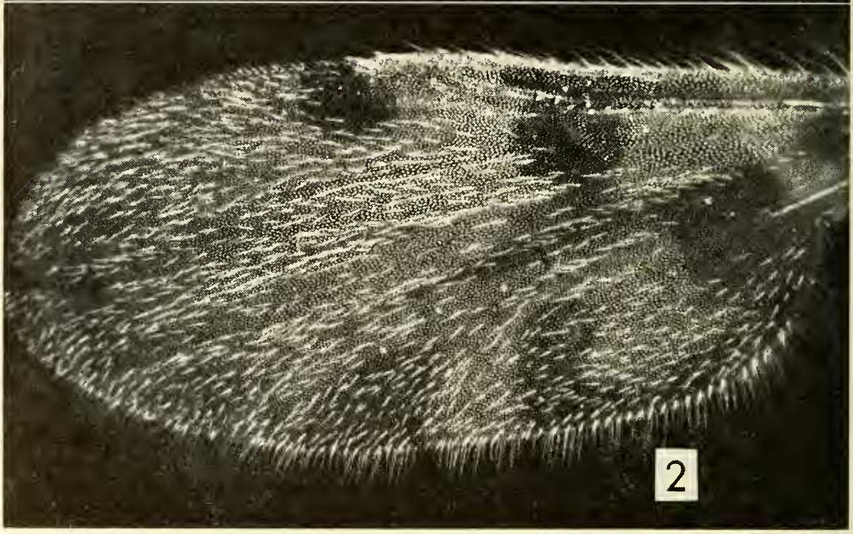


FIG. 1. Phase contrast dark field of wing of *Culicoides byersi*, new species. FIG. 2. Phase contrast dark field of wing of *Culicoides sublettei*, new species.

Types of the species described as new in this paper will be deposited in the United States National Museum, and as many paratypes as possible will be deposited in the Snow Entomological Museum of the University of Kansas and the American Museum of Natural History. A determined series of the New Mexico species will be deposited in the Snow Entomological Museum.

All measurements used were made with an ocular grid calibrated with a stage micrometer and most were taken from slide-mounted specimens which had been cleared in potassium hydroxide or from specimens cleared in phenol. Measurements, when possible, were made of a series of specimens so as to give some insight into the variation of the structures. The results are presented as the mean followed (in parentheses) by the range of variation and N, the number of specimens measured; for example, 1.68 (1.5-1.8; N=3). Measurements not given in this fashion refer to single specimens.

Drawings were made with the aid of a Bausch and Lomb V-H microprojector. No attempt was made to correct the symmetry of most of the drawings, since this could have led to distortion of some of the structures.

The illustration of the dark and pale wing spots in this paper was achieved by using Craf-Tone, a commercial stippling paper. This technique is limited in that one cannot show decreasing or increasing intensity of the wing color. This, however, is not of great taxonomic value and the ease by which this material can be applied compared to stippling by hand greatly overshadows this limitation.

## MORPHOLOGY

The head is subspherical, anteriorly flattened and possesses a broad postocciput. The vertex is undifferentiated and usually contains scattered setae. The eyes are large reniform structures and are bare or rarely have short pubescence among the ommatidial facets. The eyes may be contiguous or separated; the degree of marginal contact or separation is of importance in distinguishing some species. The ocelli are more or less poorly differentiated. The frons can be arbitrarily delimited posteriorly in most species by a transverse transocular suture, which arose secondarily. It probably gives support in the area of the eyes and is quite evident, particularly in species with rather widely separated compound eyes.

One can readily postulate that if this secondary suture functions for support of this area, the appearance of a second suture with a similar function is possible. Indeed, this appears to be borne out in certain species of *Culicoides*, e.g., *C. sublettei* n. sp., and *C. stellifer,* in which there is a small interocular suture anterior to the transocular suture.

The frontoclypeus surrounds the antennal bases in the region of the frons and is expanded anteriorly to form the convex clypeal region. Its strongly incurved border is joined with the labrum-epipharynx by two small, triangular sclerites designated by Peterson (1916) as tormae. An important taxonomic character involves a ratio of the head and proboscis. The length of the proboscis is measured from the distal end of the labrum-epipharynx to the anterior margin of the tormae. This length is divided into the length measured from the anterior margin of the tormae to the median hair socket.

Jamnback (1965), in his paper on the *Culicoides* of New York, has defined this character as given here; however, he has inverted the fraction when applying it to a description and said that a "proboscis-to-head ratio" of less than 0.65 should be indicative of a short proboscis; however, it should indicate a long proboscis. Therefore, no comparison could be made with regard to this character between eastern and southwestern representatives of several species.

The biting apparatus includes the labrum-epipharynx, mandibles, maxillae, labium and the hypopharynx. The mandibular, hypopharyngeal and maxillary stylets are enclosed in a labial gutter, covered dorsally by the labrum; the sucking apparatus consists of cibarial and pharyngeal pumps (=pharynx and oesophageal pumps, respectively, of Jobling, 1928). The mandibles of the females are thin blades, finely toothed on the distal margins, the number of mandibular teeth being of value in separation of closely related species. Various authors have shown a device which interlocks the mandibles to give a scissor-like appearance. The endite lobe of the maxilla, usually extended as a maxillary stylet, is believed to be the galea or fused galea and lacinia. On the basis of musculature, the action of the maxillae appears to be protraction and retraction. The labium and hypopharynx are distally toothed.

The mandibles of the females in the majority of blood-feeding species in the genus *Culicoides* are prominently denticulate. The females of other species have weakly developed mouthparts and are apparently incapable of taking a blood meal. Jamnback (1965) has illustrated both hematophagous and non-hematophagous types of mouthparts.

The maxillary palps are five-segmented, the first segment short and incompletely sclerotized, the third segment large and more or less swollen. The third palpal segment bears on the mesal surface a specialized sensory organ which contains many small sensillae. Barth (1961) described the histological aspects of this organ in *Forcipomyia*, a genus related to *Culicoides*.

The maxillary palps of females possess characters, such as the ratio of lengths of segments and the shapes of the third segment and sensory pit, which have been used by many workers for the delimitation of species. The palpal ratio (PR) is obtained by dividing the length of the third palpal segment by its greatest breadth. This measurement is subject to variation, particularly in slide-mounted specimens, due to the orientation of the palpus on the slide; however, it is still of importance in the separation of some species. The relative lengths of the palpal segments is another useful character. In this paper the basal segment is not included in palpal measurements, since its degree of sclerotization appears to vary among individuals of the same species.

The mouthparts of the males, although structurally similar to those of the females, are less well developed. They have no distal mandibular teeth; the mouthparts are not fitted for piercing; and the maxillary palps are not as well developed as in females.

The antennae provide some of the most useful characters for distinguishing species. They are divided into 15 units: a small ring-like scape, which is more or less hidden by the enlarged pedicel, and a flagellum composed of 13 sub-segments. In various instances in the remainder of this paper the antennal sub-segments, or flagellomeres, will be referred to as "segments." In the females the proximal eight flagellomeres are short, being slightly longer than wide, while the distal five are elongate, usually much longer than wide. Segment 3 is elongate and somewhat larger than 4-10. Segments 3-10 in the female possess long verticils. In males the pedicel is more enlarged than in females, and the transition in flagellar structure occurs between segments 12 and 13. Segments 3-12 each have dense verticillate hairs, giving the male antenna a plumose appearance.

The antennal segments contain various types of sensory organs, one of which is very important taxonomically. Jobling (1928) first demonstrated the presence of small pits on various segments and referred to them as olfactory pits. These pits, which are surrounded by a number of minute setulae, are found on the third segment of both sexes and various other segments in females and some males. First used taxonomically by Ortiz (1951), their pattern of distribution is more or less consistent for a species and, therefore, very useful in the separation of species and species groups. Antennal sensillae (*sensu* Jobling) are usually evident under low magnification in slide-mounted preparations. A second type of sensilla on the antennal segments has been described by Campbell and Pelham-Clinton (1960). According to these authors, small flask-shaped structures occur on various antennal segments and correspond to the sensilla coeloconica described by Snodgrass (1935). No taxonomic significance has yet been assigned to the sensilla coeloconica. The use of the term sensilla in this paper, unless otherwise stated, refers to the "olfactory pits" described by Jobling.

Jamnback (1965) has shown some correlation between the number of antennal olfactory pits and the host preferences of the females. He has pointed out that females of ornithophilic species appear to have more olfactory pits than mammalophilic species preferring large mammals.

The antennal ratio is obtained by dividing the combined lengths of the distal five segments by the combined lengths of the preceding eight.

In addition to the antennal ratio, another antennal character is more or less constant for a species. This relationship involves the length of segment 11 divided by the combined lengths of segments 9 and 10.

The thorax is dorsally convex and protruding anteriorly, so as to cover the posterior region of the head slightly. The mesonotum possesses a pair of large and distinct sensory or humeral pits, which are located near the anterior margins of the humeri and are possibly remnants of the pupal respiratory horns. A pair of faint lines, the pseudosutural foveae, extend posteriorly from the pits to near the sides of the scutellum. The large, somewhat flattened, caudal portion of the mesonotum, the prescutellar depression, possesses a pair of sensory areas known as the prescutellar spots. The postscutellum is bare and arched. In many species the mesonotal disc is ornamented by a distinct pattern, which along with various other thoracic markings, is of use in species differentiation.

The legs are slender; however, the femora occasionally may be slightly expanded, but are not spinous and bear no scales, as in many of the other ceratopogonid genera. The hind tibiae bear a comb of spines, which is sometimes useful in differentiating species. The basal tarsomere is at least twice as long as the second, and the fourth tarsomere is shorter than the fifth. The shape of the fourth tarsomere is important in distinguishing the subgenus *Macfiella* Fox and some other unrelated species. The pretarsal claws are small, simple, and equal in both sexes and a very minute empodium arises from the apical end of the unguitractor.

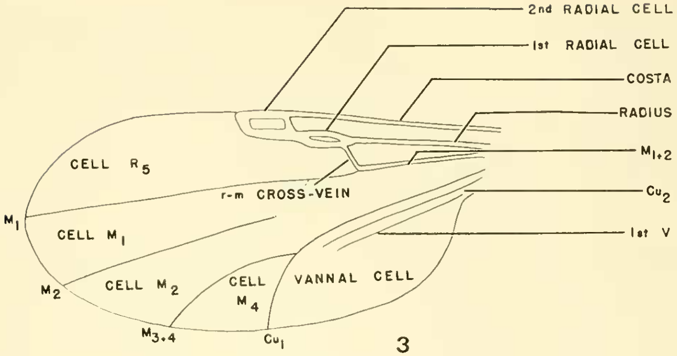
The wings possess two types of hairs: macrotrichia, which are long hairs whose abundance may vary between species, and dense microtrichia, whose presence or scarcity at a particular location makes a pattern of light or dark spots, which are of great importance in the recognition of species. These pale spots can be very stable in position and distinctiveness in some species, but certain spots may be highly variable in others.

The costa extends approximately one-half the length of the wing, the proportion being a useful taxonomic character in some species. There are two radial cells which are usually of subequal length, the distal cell being broader than the slit-like proximal cell. The nomenclature of the wing veins used in this study follows the Tillyard modification of the Comstock-Needham system, in which the anterior branches are $M_1$ and $M_2$, and the posterior branches are $M_{3+4}$ and $Cu_1$ (Fig. 3).

The terms vannal vein and vannal cell used in this work are considered to be morphologically more correct than the terms anal vein and anal cell used by previous authors. The vannal portion of the wing refers to the fan-shaped area delimited basally by the third axillary sclerite and anteriorly by the vannal fold. Although the term anal vein is firmly entrenched in the taxonomic literature of this group, it is incorrect, according to current morphological thinking and is in need of change.

The wings of the males are usually more elongate than those of females, and the pattern of light spots usually lacks the contrast seen in the female wing. The measurement of wing length was made from the basal arculus to the tip. This measurement appears to be more accurate than the practice of adding one-seventh to the wing length to account for that part of the wing basad to the basal arculus, utilized by some workers.

The external features of the female abdomen are usually of little taxonomic importance and are easily discolored as a result of engorgement. The internal abdominal structures are, however, of paramount importance. The sclerotized



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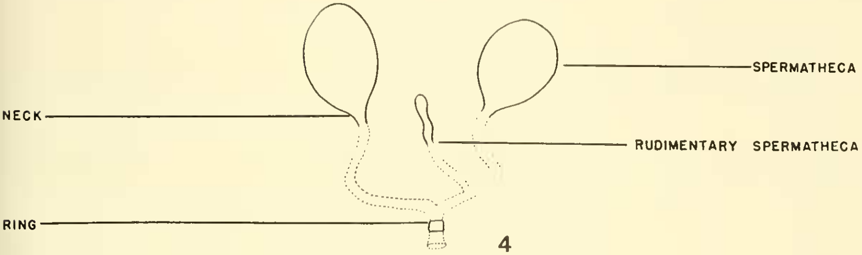

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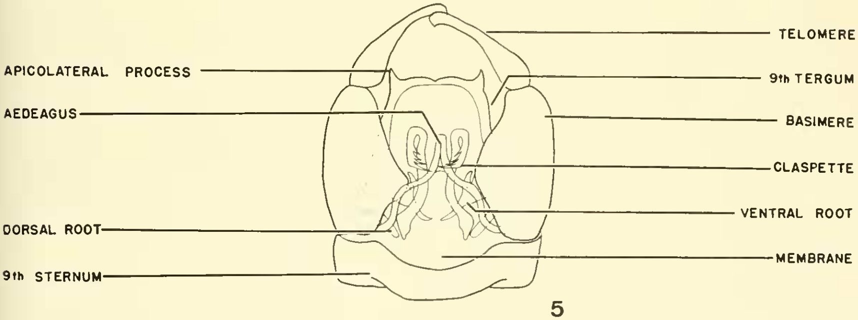

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FIG. 3. Wing of *Culicoides*. FIG. 4. Spermathecal system of *Culicoides*. FIG. 5. Male genitalia of *Culicoides baueri* Hoffman.

parts of the spermathecal system (Fig. 4) are very significant, and females of many species cannot be accurately identified without reference to it. The spermathecae may or may not be sclerotized and may vary in number from one to three, the number being constant for a particular species. Those species having two functional spermathecae usually have a rudimentary sclerotized spermatheca, which is rarely expanded to resemble a small third functional spermatheca. The spermathecal ducts may be sclerotized for some distance distally but are unsclerotized proximally near their connection to the bursa copulatrix. The junction, which forms the union of the spermathecal ducts and the bursa, may be marked by a small sclerotized ring. Length of the spermathecae was measured from the distal end to the proximal end of the sclerotized portion of the duct, and width was measured at the widest point.

The abdomen of the male is considerably more slender than that of the female. The genitalia of the male (Fig. 5) are of primary importance in the recognition of species and higher taxa. In this study I have followed the revised interpretation of the male genitalia proposed by Snodgrass (1957, 1959). This concept is in agreement with the earlier morphological ideas of Crampton (1942) and more recently the studies of Matsuda (1958). It is supported in the Diptera by the embryological studies of Christophers (1922), Christophers and Barraud (1926) and Abul-Nasr (1950), and in my opinion is more plausible than the earlier idea of appendicular origin of genitalia.

Taxonomists of the Ceratopogonidae have long chosen to follow a terminology for the male genitalia that is, in many instances, without meaningful morphological basis. This condition, however, is not limited to the Ceratopogonidae. Crampton (1942) pointed out some of the confusion that exists regarding the nomenclature of various structures and made a plea for uniformity. This uniformity has been met in some groups by the use of taxonomically adequate, but morphologically inaccurate, terms. Although there is something to be said for uniformity of nomenclature, one should strive for morphological accuracy to facilitate uniformity in concepts of homology.

The ninth abdominal segment of the male is in the form of an irregular scleroma composed of the fused tergum and sternum. The ninth tergum is a posteriorly tapering, platelike expansion, the posterior margin of which may or may not bear apicolateral processes. The ninth sternum is a narrow structure, usually emarginate on the posterior surface. The outermost genital claspers, the parameres, articulate on the ninth sternum and are divided into a proximal basimere and a distal telomere (basistyle and dististyle, respectively, of authors). The suffix "-style," used by many authors in the terminology for the outermost male genital claspers, invokes the old idea of the appendicular origin of the male genitalia and is not consistent with the terminology proposed in this paper. The term "paramere" has been affixed to many different structures of the genitalia, but in reality is the lateral genital clasper. Some workers have gone so far as to suggest abandoning this term because of the confusion as to its true identity. The basimere (Fig. 5), in the generalized condition, has two internal processes on the anterior surface, the inner ventral root and the outer dorsal root. The telomere generally has an expanded base and narrows distally and may have a curved-tipped apical spine. The claspettes (parameres of authors) are usually elongate with an expanded base and a simple, slender to greatly modified apex. In the subgenus *Selfia* Khalaf, the claspettes are fused into a platelike structure. The aedeagus is usually a V-or Y-shaped structure, less sclerotized distally, with a pair of basal arms. Its basal arch is usually curved and is connected to the ninth sternum by a membrane, which may or may not be spiculate.

## SYSTEMATICS

The Ceratopogonidae show morphological affinity to the Chironomidae but differ in that they possess complete mouthparts, having developed mandibles in both sexes, and a branched $M_{1+2}$ wing vein, and a postscutellum lacking a median furrow or keel. The legs of ceratopogonids appear stouter and the metathoracic pair is usually longer, as is the prothoracic pair of chironomids. Edwards (1939) is of the opinion that the ceratopogonids have much in common with the Simuliidae.

The genus *Culicoides* can be differentiated from other ceratopogonids by the presence of two more or less equal radial wing cells, small and equal tarsal claws in both sexes, the absence of a hairy empodium, and large pronounced thoracic humeral pits.

Root and Hoffman (1937) proposed the first supraspecific categories of *Culicoides* when they divided the North American species into two series on the basis of male genitalia and certain external characters. Edwards, in his monograph of the British species (1939), was able to substantiate such a division and placed the European species into two apparently natural groups on the basis of the male genitalia.

Fox (1948) proposed the subgenus *Hoffmania* for 12 neotropical species, which he distinguished from *Culicoides s. str.* The known species of *Hoffmania* were later reviewed by Ortiz (1950), who expanded the subgenus to include several additional species.

Khalaf (1954) made the first major attempt to establish interrelationships and deduce phylogenies among species of *Culicoides*. Using primarily external male genitalia and female spermathecae, he was able to divide the known world fauna into four subgenera: *Culicoides s. str., Monoculicoides* Khalaf, *Oecacta* Poey and *Selfia* Khalaf, lumping the subgenus *Hoffmania* of Fox into the subgenus *Oecacta* Poey. Khalaf further subdivided these subgenera into complexes and species groups, and although his concepts were fundamentally sound, he was handicapped in that he had to draw much of his information from the literature, which was, no doubt, vague in many instances. Many of the species descriptions in the literature made little reference to the genitalia; therefore, the true relationship of these with other species could not be accurately determined.

Vargas (1953) erected the subgenus *Beltranmyia* for the *crepuscularis* group, which Khalaf had included in *Monoculicoides*. Fox (1955), in his catalog of bloodsucking midges, arranged the species of *Culicoides* known to occur in the Americas into subgenera, introduced the subgenus *Macfiella* for the *phlebotomus* group and *Avaritia* for the *obsoletus* group, and augmented the subgenus *Beltranmyia* as Vargas had outlined it. In spite of these changes, the subgeneric classification of Fox is not entirely in agreement with the earlier attempt by Khalaf with respect to the content of the various subgenera.

More recently Wirth and Hubert (1959) have proposed the subgenus *Trithecoides* for the Ethiopian and Oriental species whose females have three well-developed spermathecae and a long second radial cell.

Vargas (1960), attempting to correlate genitalia and wing characters, proposed the following new subgenera for the species occurring in the Western Hemisphere: *Anilomyia, Diphaomyia, Drymodesmia, Glaphiromyia* and *Mataemyia.* In addition he resurrected the name *Haematomyidium* Goeldi 1905 for many species usually placed in the subgenus *Oecacta.*

Incorporating two of the subgeneric names of Vargas (1960), i.e., *Drymodesmia* for the *copiosus* group and *Diphaomyia* for the *iriartei-baueri* group, with previously known names, Wirth (1965) arranged the North American species into nine subgenera. In my opinion the classification by Wirth (1965), which differs from that of Vargas (1960) in the content of several of the subgenera, reflects more correctly in many instances the natural affinities of the genus. It is the classification followed in this paper.

Some subgenera, e.g., *Oecacta,* in the past have been considered as "catch-alls" for a rather heterogeneous accumulation of species. Attempts have recently been made to divide various subgenera into much smaller units. Although in some instances such divisions may be useful in pointing out interspecific relationships, there is little to be gained at present by assigning subgeneric names to a large number of species groups that would contain only a few species. As more information becomes available, much shifting of taxa may become necessary. It is only after more distributional data are available and extensive taxonomic studies, such as that of Wirth and Blanton (1959), have been made that more accurate conclusions regarding phylogenetic relationships can be drawn.

Further studies, such as those of Jones (1961), are needed to correlate the classification of the immature stages with that of the adults. These studies should reveal interspecific relationships not evident in classifications based on adults. Several of the newer systematic techniques, e.g., numerical taxonomy, should show considerable promise at the subgeneric level.

At the outset of this investigation nine species of *Culicoides* were reported in the literature as occurring in New Mexico (Wirth, 1952, 1965; Foote and Pratt, 1954). Extensive collecting has increased this number to 35. Nineteen species can be assigned to previously existing names, the remainder are considered as new to science. Adequate material is available to describe four of these as new species. It is hoped that subsequent collection will allow description of the remaining species. One species, *C. pampoikilus* Macfie, previously reported from Mexico, Panama and Venezuela, was taken during this study at Ruidoso, Lincoln County, and is a new United States record.

The *Culicoides* fauna of New Mexico can be divided into eight subgenera. In the descriptive portion of this paper many species, particularly those placed in the subgenus *Oecacta,* are listed, when applicable, with the name of their respective species group. The following table gives the systematic arrangement of New Mexico species together with a summary of the mean values of a number of quantitative characters. The range of variation is given in the respective species descriptions.

TABLE 1. Systematic arrangement and summary of quantitative characters of New Mexico *Culicoides.*

| Species | Wing Length | Costal Ratio | Antennal Ratio | Ratio of Antennal Segments 9+10 to 11 | Sensorial Pattern | Palpal Ratio | Head Length to Proboscis Ratio | No. Mandibular Teeth | No. Tibial Spines |
|---|---|---|---|---|---|---|---|---|---|
| Subgenus *Avaritia* | | | | | | | | | |
| *obsoletus* | 1.19 | 0.60 | 1.14 | 0.72 | 3, 11-15 | 2.74 | 1.0 | 12-16 | 5 |
| Subgenus *Beltranmyia* | | | | | | | | | |
| *crepuscularis* | 1.41 | 0.56 | 1.35 | 0.90 | 3-14(15) | 2.27 | 1.05 | 10-16 | 4 |
| Subgenus *Culicoides* | | | | | | | | | |
| *cockerellii* | 1.84 | 0.60 | 1.07 | 0.71 | 3, 5, 7, 9-15 | 3.26 | 1.05 | 14-16 | 6 |
| Subgenus *Diphaomyia* | | | | | | | | | |
| *baueri* | 1.35 | 0.52 | 1.07 | 0.66 | 3, 5-10 | 2.17 | 1.24 | 10-12 | 4 |
| *haematopotus* | 1.17 | 0.55 | 1.43 | 0.91 | 3, 5, 7, 9-15 | 2.5 | 1.11 | 12-15 | 4 |
| Subgenus *Drymodesmyia* | | | | | | | | | |
| *sitens* | 1.34 | 0.51 | 1.07 | 0.69 | 3-9, (10) 11-15 | 2.33 | 1.0 | 14 | 4 |
| *byersi* | 0.89 | 0.54 | 1.13 | 0.73 | 3, 5, 7, 9, 11-15 | 1.7 | 1.67 | 9-10 | 4 |
| Subgenus *Monoculicoides* | | | | | | | | | |
| *variipennis sonorensis* | 1.55 | 0.55 | 0.86 | 0.59 | 3, (4) (5) (6) (7), 8-10 | 2.38 | 1.10 | 11-15 | 6-7 |
| Subgenus *Oecacta* | | | | | | | | | |
| *doeringae* | 1.24 | 0.58 | 1.63 | 1.11 | 3, 5, 7, 9, 11, 13-15 | 2.61 | 1.12 | 12-15 | 4 |
| *luglani* | 1.22 | 0.53 | 0.95 | 0.59 | 3-10 | 2.12 | 1.05 | 13-16 | 4 |
| *novamexicanus* | 1.23 | 0.56 | 1.02 | 0.58 | 3-5, 7, 9, 11, 13-15 | 2.12 | 1.04 | 14-16 | 4 |
| *oklahomensis* | 1.21 | 0.56 | 1.29 | 0.82 | 3, 5, 7, 9, 11-15 | 3.0 | 1.04 | 14 | 5 |
| *palmerae* | 1.48 | 0.56 | 1.28 | 0.77 | 3-15 | 2.26 | 1.02 | 14 | 4 |
| *pampoikilus* | 1.52 | 0.54 | 1.55 | 0.89 | 3, 5, 7, 9, 11-15 | 2.0 | 1.32 | 15 | 4 |

TABLE 1. Systematic arrangement and summary of quantitative characters of New Mexico *Culicoides* (concluded).

| Species | Wing Length | Costal Ratio | Antennal Ratio | Ratio of Antennal Segments 9+10 to 11 | Sensorial Pattern | Palpal Ratio | Head Length to Proboscis Ratio | No. Mandibular Teeth | No. Tibial Spines |
|---|---|---|---|---|---|---|---|---|---|
| *pecosensis* | 1.22 | 0.54 | 1.25 | 0.81 | 3-7, 9, 11-14 | 2.48 | 0.93 | 17-18 | 5 |
| *reevesi* | 0.85 | 0.56 | 0.65 | 0.33 | 3, 8-10 | 2.1 | 1.16 | 14-16 | 4 |
| *stellifer* | 1.24 | 0.54 | 0.96 | 0.62 | 3, 7-10 | 2.47 | 1.22 | 12-14 | 5 |
| *stonei* | 1.17 | 0.56 | 1.10 | 0.69 | 3-14(15) | 2.3 | 1.04 | 12-13 | 4 |
| *sublettei* | 1.19 | 0.55 | 1.07 | 0.67 | 3, 11-15 | 2.37 | 1.05 | 14-16 | 4 |
| *utahensis* | 1.43 | 0.55 | 1.12 | 0.75 | 3-15 | 1.85 | 1.30 | 14 | 4 |
| Subgenus *Selfia* | | | | | | | | | |
| *brookmani* | 1.14 | 0.53 | 0.92 | 0.62 | 3-10 | 1.97 | 1.39 | 11 | 4 |
| *hieroglyphicus* | 1.20 | 0.54 | 1.03 | 0.66 | 3, 5-10 | 2.11 | 1.24 | 11-13 | 4-5 |
| *jamesi* | 1.27 | 0.56 | 1.0 | 0.63 | 3-10 | 2.26 | 1.27 | 11-13 | 4-5 |

## KEY TO FEMALES OF NEW MEXICO *CULICOIDES*

1. Spermathecae unsclerotized; wings without pattern of light and dark spots. .......... 2
Spermathecae sclerotized; wings with or without pattern of spots. .......... 3
2. Sensoria on antennal segments 3-10. .......... *brookmani*[1]*
Sensoria on antennal segments 3, 5-10. .......... *jamesi*[3]
.......... *hieroglyphicus*[2]
3(1). Second radial cell with distal portion in a pale area (Fig. 18, 23) eyes contiguous. .......... 4
Second radial cell in a dark area; eyes may or may not be contiguous. .......... 5
4(3). Wings poorly marked; sensoria on segments 3, 11-15; hind tibial comb with 5 spines; a small to medium sized species, WL 1.0-1.3 mm. .......... *obsoletus*[5]
Wings well marked, with 3 transverse bands (Fig. 18) which may be reduced in some forms; sensoria irregularly distributed, usually 3, 5, 7, 9, 11-15; hind tibial comb with 6 spines; a large species, WL 1.6-2.0 mm. .......... *cockerellii*[4]
5(3). One spermatheca. .......... 6
Two spermathecae. .......... 8
6(5). Wing pattern with irregular gray streaks (Fig. 33); hind tibial comb with 6-7 spines; spermatheca C-shaped. .......... *variipennis*[7]
Wing pattern with definite pattern of spots; hind tibial comb with 4 spines; spermatheca not as above. .......... 7
7(6). Antennal segments 9+10 to 11 in ratio of 0.90; sensoria on segments 3-15; a large species, WL 1.1-1.5. .......... *crepuscularis*[6]
Antennal segments 9+10 to 11 in ratio of 0.30; sensoria on segments 3, 8-10; a small species, WL 0.8 mm. .......... *reevesi*[17]
8(5). Hind tibial comb with 5-6 spines. .......... 9
Hind tibial comb with 4 spines. .......... 11

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* Number in brackets refers to location in species descriptions.

9(8). Apices of veins $M_1$, $M_2$, $M_{3+4}$ dark; cell $R_5$ with inverted U-shaped pale spot (Fig. 69); sensoria usually on segments 3, 7-10. ..... *stellifer*[13]
Apices of veins $M_1$, $M_2$, $M_{3+4}$ pale; cell $R_5$ not as above; sensoria on various proximal segments and on 11-15. ..... 10

10(9). Vein $Cu_1$ bordered by a pale spot for at least part of its length (Fig. 105). ..... *oklahomensis*[19]
Vein $Cu_1$ dark (Fig. 99). ..... *pecosensis*[18]

11(8). Wing without distal pale spots (Figs. 77, 82). ..... 12
Wings with distal pale spots. ..... 13

12(11). Wings completely lacking pattern of spots; sensoria on segments 3-14(15). ..... *stonei*[14]
Wings with very faint markings; sensoria on segments 3, 11-15. ..... *sublettei*[15]

13(11). Spermathecae very unequal, lacking necks (Fig. 122); antennal segments 9+10 to 11 in ratio of at least 1.0; sensoria on segments 3, 5, 7, 9, 11, (12) 13-15. ..... *doeringae*[23]
Spermathecae equal or subsequal, necks usually present; segments 9+10 longer than 11, in ratio of less than 1.0; sensoria various. ..... 14

14(13). Cell $R_5$ with 3 pale spots (Fig. 88). ..... *pampoikilus*[16]
Cell $R_5$ with 2 pale spots. ..... 15

15(14). Pale bands absent on femora; eyes separated by approximately diameter of an ommatidial facet; macrotrichia abundant over entire surface of wing. ..... 16
Some or all femora with pale bands; eyes usually separated less than diameter of ommatidial facet to contiguous; macrotrichia usually confined to distal and posterior regions of wing. ..... 18

16(15). Sensoria on segments 3-5, 7, 9, 11, 13-15. ..... *novamexicanus*[22]
Sensoria on segments 3-15. ..... 17

17(16). Proboscis long, HR 0.8-1.1; wing well marked; third palpal segment moderately swollen, PR 2.0-2.4; spermathecae without necks. ..... *palmerae*[20]
Proboscis of medium length, HR 1.30; wing poorly marked; third palpal segment greatly swollen, PR 1.85; spermathecae with necks. ..... *utahensis*[21]

18(15). Sensoria on segments 3, 5-10, 3, 7-10, or 3-10, never on distal five segments. ..... 19
Sensoria on segments 3, 5, 7, 9, (10) 11-15 or 3-15. ..... 20

19(18). Spots in cells $M_1$, $M_2$ and $M_4$, small, round, well removed from wing margin (Fig. 55) veins $M_{3+4}$ and $Cu_1$ bordered by pale area; spot in cell $R_5$ constricted mesally; sensoria on segments 3, (5), (6), 7-10. ..... *baueri*[10]
Spots in cells $M_1$, $M_2$ and $M_4$ large, those in $M_2$ and $M_4$ attaining wing margin (Fig. 66) veins $M_{3+4}$ and $Cu_1$ not as above; spot in $R_5$ large, not constricted; sensoria on segments 3-10. ..... *luglani*[12]

20(18). Antennal segments 9+10 to 11 subequal, in ratio of 0.83-1.0; AR 1.25-1.57; pale spot in cell $R_5$ small at distal end of cell (Fig. 60). ..... *haematopotus*[11]
Segments 9+10 to 11 unequal, in ratio of approximately 0.69-0.75; AR not more than 1.15; pale spot in cell $R_5$ mesally located. ..... 21

21(20). Proboscis very short, HR 1.5-1.7; pale spot on basal portion of vein $M_1$ absent (Fig. 49); a small species, WL 0.89 mm. ............ *byersi*[9]
Proboscis of medium length, HR 1.0; mesally constricted pale spot in cell $R_5$, attaining anterior wing margin; pale spots over basal portions of veins $M_1$ and $M_2$ (Fig. 44); a medium sized species, WL 1.3 mm. .................................................................... *sitiens*[8]

## KEY TO MALES BASED UPON GENITALIA*

1. Claspettes fused for part or all of length (Figs. 12, 38). ......................... 2
Claspettes free and separate for entire length. ........................................... 5

2(1). Claspettes fused basally, apices free; aedeagus with bifid tip (Fig. 38). .............................................................................. *variipennis*[7]**
Claspettes completely fused over entire length. ........................................... 3

3(2). Ninth sternum without mesal notch or lobes; telomere unmodified; boomerang-shaped sclerites present. .................... *brookmani*[1]
Ninth sternum with prominent lobes or mesal notch; telomere modified apically; boomerang-shaped sclerites absent. ............................. 4

4(3). Ninth sternum with prominent caudo-median lobes; aedeagal arms widely separated. ........................................................... *hieroglyphicus*[2]
Ninth sternum with medio-posterior notch; aedeagal arms not widely separated; telomere distinctly modified with large foot-shaped apex (Fig. 17). .............................................................. *jamesi*[3]

5(1). Ninth tergum with apicolateral processes absent or very small (Figs. 22, 27); if small, medio-caudal margin very convex and extending posteriorly beyond tip of apicolateral processes; mesal notch of posterior border of ninth tergum absent. ................................ 6
Apicolateral processes present and usually well developed; mesal notch present. ........................................................................................... 7

6(5). Ventral root very long and slender, much longer than dorsal root; ninth sternum with deep mesal notch (Fig. 27); apicolateral processes absent. ....................................................................... *obsoletus*[5]
Dorsal and ventral roots subequal in length; ninth sternum with only slight emargination; ninth tergum with apicolateral process very small, medio-caudal margin very convex (Fig. 22). .... *cockerellii*[4]

7(5). Claspette with distinct apical and subapical spines (Figs. 64, 70, 87, 122). .................................................................................................. 8
Claspette with simple apex (Figs. 32, 104, 115). ........................................ 13

8(7). Ventral root with process on posterior margin (Figs. 65, 129). ............ 9
Ventral root lacking process. ...................................................................... 12

9(8). Aedeagal arms with blade-like processes on posterior margin (Fig. 65). 10
Aedeagal arms without blade-like processes. ............................................... 11

10(9). Claspette with distinct thumb-like lobe on lateral margin, apex greatly expanded with row of prominent spines. ........ *haematopotus*[11]
Claspette lacking thumb-like lobe, apex not expanded. ............ *baueri*[10]

11(9). Claspette with small lateral lobe at approximately two-thirds of length; aedeagus in shape of inverted V, basal arch mesally notched, median posterior process short, conical. ...................... *stellifer*[13]

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* Male of *reevesi* unknown.

** Number in brackets refers to location in species descriptions.

Claspette tapering to distal point bearing row of spines along margin; aedeagus with elongate, truncate median process, basal arch rounded. .......... *doeringae*[23]

12(8). Claspette with fringe of spines, stem with prominent blade-like process on lateral margin (Fig. 69); median process of aedeagus with pointed lateral subapical processes. .......... *luglani*[12]

Claspette with 2-3 subapical spines, stem simple (Fig. 86); aedeagus truncate, lacking subapical projections. .......... *sublettei*[15]

13(7). Ventral root greatly reduced or absent (Fig. 33); membrane spiculate. .......... *crepuscularis*[6]

Ventral root present and distinct; membrane may or may not be spiculate. .......... 14

14(13). Telomere bulbous basally, abruptly bent (Fig. 109); apicolateral processes distinct, of uniform width for most of length, much longer than wide; medio-caudal border of ninth tergum convex with distinct mesal notch. .......... 15

Telomere not abruptly bent; apicolateral processes usually triangular; medio-caudal border of ninth tergum not distinctly convex. .. 17

15(14). Aedeagus with lateral shoulder-like processes on median posterior process (Fig. 112); claspette with tapering, usually recurved apex. .......... *palmerae*[20]

Aedeagus lacking processes; apex of claspette usually not recurved. .... 16

16(15). Claspette slender with contorted apex. .......... *novamexicanus*[22]

Claspette stout with laterally directed apex. .......... *utahensis*[21]

17(14). Median posterior process extended to slender point with subapical processes (Fig. 105). .......... *oklahomensis*[19]

Median process not as above, lacking subapical processes. .......... 18

18(17). Claspettes with median portion of stems distinctly swollen, apex abruptly narrowed (Fig. 101); median posterior process elongate, parallel-sided truncate, about equal in length to basal arms. .......... *pecosensis*[18]

Claspettes tapering distally to simple pointed apex; median process not elongate or parallel-sided. .......... 19

19(18). Apicolateral processes broad, very prominent, triangular (Figs. 79, 91); claspette with distinct, anteriorly directed basal process. .......... 20

Apicolateral processes slender, pointed; claspettes not as above. ........ 21

20(19). Median posterior process slender with slight subapical swelling (Fig. 93); basal arch notched mesally; claspette slender, tapering to mesally recurved apex; membrane bare. .......... *pampoikilus*[16]

Median process broad, subtruncate without median swelling; claspette with rather stout, laterally turned sickle-shaped apex; apicolateral processes very large (Fig. 81); membrane spiculate. .......... *stonei*[14]

21(19). Aedeagus very stout, conical, arms and basal arch short; claspettes with basal portion of stem swollen, knob-like, tapering to slender pointed, laterally directed tips; ninth sternum very narrow. .... *sitiens*[8]

Aedeagus with long slender arms, basal arch of medium length; claspettes tapering for entire length, apices entwined. .......... *byersi*[9]

## Subgenus *SELFIA* Khalaf, 1954:38

Type species *hieroglyphicus* Malloch (orig. des.).

This group of small to medium sized species contains females which have unsclerotized, therefore unapparent, spermathecae and plain wings, without a pattern of pale and dark spots. The antennal sensoria are located on various of the proximal 8 segments, depending on the species, but never on the distal 5. The hind tibial comb contains 4 or 5 spines. The claspettes of the male genitalia are fused into a platelike structure. The ventral root of the basimere is prominent; however, the dorsal root is often unapparent. Two lateral sclerites, often fused distally, usually comprise the adeagus. The unmarked wings of *stonei* James and *bottimeri* Wirth superficially resemble those of the *Selfia* species; however, these species can be readily distinguished by the well sclerotized spermathecae and the distinctive male genitalia.

*Selfia* is apparently restricted to the Nearctic region, as no neotropical forms have been described. This group reaches its highest development in the western portion of the United States, and only one species is reported east of the Mississippi.

Three species, *brookmani, hieroglyphicus* and *jamesi,* were found in New Mexico. Unless otherwise stated, all distribution records of *Selfia* species in this paper refer to males which have characteristic genitalia.

### 1. **Culicoides (S.) brookmani** Wirth

(Figs. 6-9)

*Culicoides brookmani* Wirth, 1952, Univ. Calif. Pub. Ent. 9:179 (male, female; California; fig. male genitalia, wing and palp).

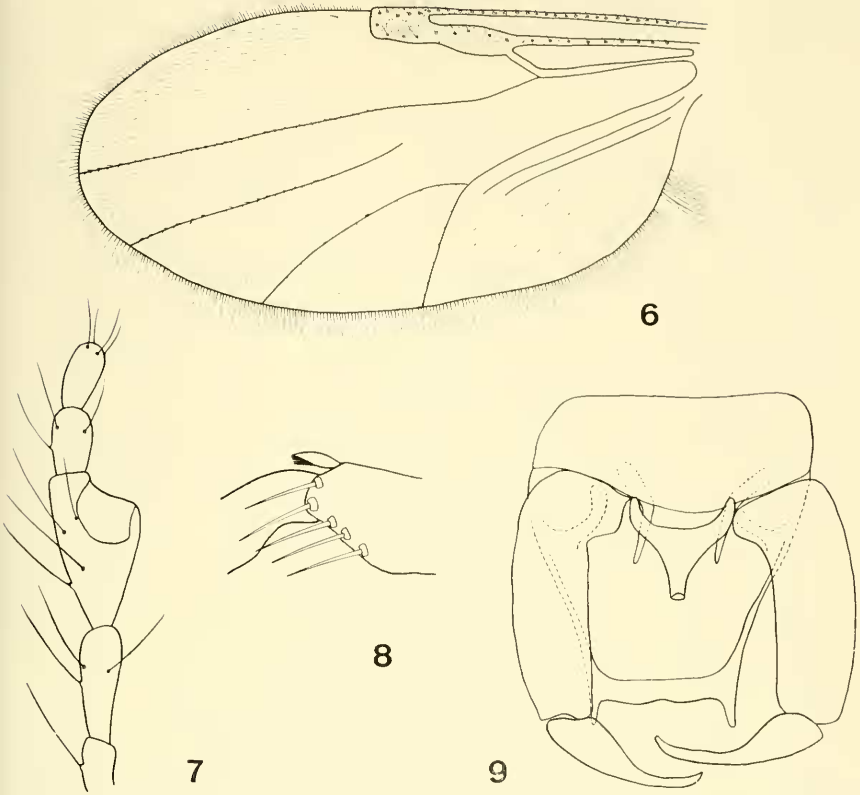
FEMALE—Length of wing 1.14 (1.04-1.27; n=4) mm.

*Head:* Eyes separated less than diameter of a facet. Antenna with flagellomeres in proportion of 13:10:10:11:12:12:12:13:14:14:15:15:21; antennal ratio 0.92 (0.82-0.97; n=4); distal sensory tufts present on segments 3-10; segments 9+10 to 11 in ratio of 0.62 (0.61-0.65; n=4). Distal four palpal segments in proportion of 15:25:8:12; third palpal segment short, very swollen, 1.97 (1.8-2.09; n=4) times as long as greatest breadth, with a large, very deep sensory pit; interior of pit lined with stalked sensillae (Fig. 7). Ratio of length of head to proboscis 1.39 (1.38-1.42; n=4). Mandible with 11 teeth.

*Thorax:* Legs unicolorous light brown; hind tibial comb with 4 or 5 spines (Fig. 8).

*Wing:* (Fig. 6). No pattern of pale and dark spots. Costa extending 0.53 (0.51-0.56; n=4) of total length of wing. Macrotrichia sparse, occurring in small numbers on veins $M_1$, $M_2$, $M_4$ and vannal cell.

*Abdomen:* Spermathecae unsclerotized.



FIGS. 6-9. *Culicoides brookmani* Wirth. Female: 6, wing; 7, palpus; 8, tibial comb. Male: 9, genitalia.

MALE—(Fig. 9). Genitalia with ninth sternum broad, posterior margin indefinite; membrane spiculate. Ninth tergum tapering posteriorly, mesal notch slight, apicolateral processes rather small and tapering distally. Basimere with ventral root prominent, having a slightly curved apex; dorsal root evidently included in basal portion of basimere. Telomere broad basally, tapering to a slender tip. Aedeagus Y-shaped with widely separated basal arms; median posterior process conical, distally truncate; two distinct boomerang-shaped structures present, the posterior end of each forming an oblique angle with the anterior end. Occasionally these structures form the lateral margins of the aedeagus. Claspettes ventrally turned, invisible in most specimens or, at best, visible as narrow band. Jones and Wirth (1958) dissected the males of this species and found the claspettes fused into a plate with narrow, slightly curved, basal arms that join narrowly for approximately the middle one-third of their combined length.

*DISTRIBUTION:* Present records indicate that this species is probably restricted to the southwestern United States. It has previously been reported from Calif., Ariz., N. Mex. and Texas. New Mexico County Records: Catron, Grant.

*DISCUSSION:* At present, alcoholic and slide-mounted females in the subgenus *Selfia* are virtually inseparable. The descriptions of the females of the *Selfia* species in this paper are based on specimens from a locality where collection yielded large numbers of males of a single *Selfia* species. An extensive study is needed to determine characters useful in the separation of the species of this group.

Slide-mounted specimens *of brookmani* tentatively can be separated from those of *hieroglyphicus* by the fact that *hieroglyphicus* usually has sensory tufts on antennal segments 3, 5-10. In pointed specimens, the pattern of the mesonotal disc *of hieroglyphicus* is sufficient to distinguish it from *brookmani*, which has either an unadorned mesonotum or three longitudinal vittae, as reported by Jones and Wirth (1958) for Texas specimens.

Although no good taxonomic character exists to distinguish slide-mounted and alcoholic specimens of *brookmani* from *jamesi*, separation can sometimes be made on the basis of the large size *of jamesi*, particularly its wing length. Pointed specimens can be distinguished on the basis of two submedial, longitudinal mesonotal stripes found in *jamesi*.

## 2. **Culicoides (S.) hieroglyphicus** Malloch

(Figs. 10-13)

*Culicoides hieroglyphicus* Malloch, 1915, Ill. State Lab. Nat. Hist. Bull. 10:297 (female; Arizona; fig. mesonotal disc).

FEMALE—Length of wing 1.20 (1.12-1.23; n=8) mm.

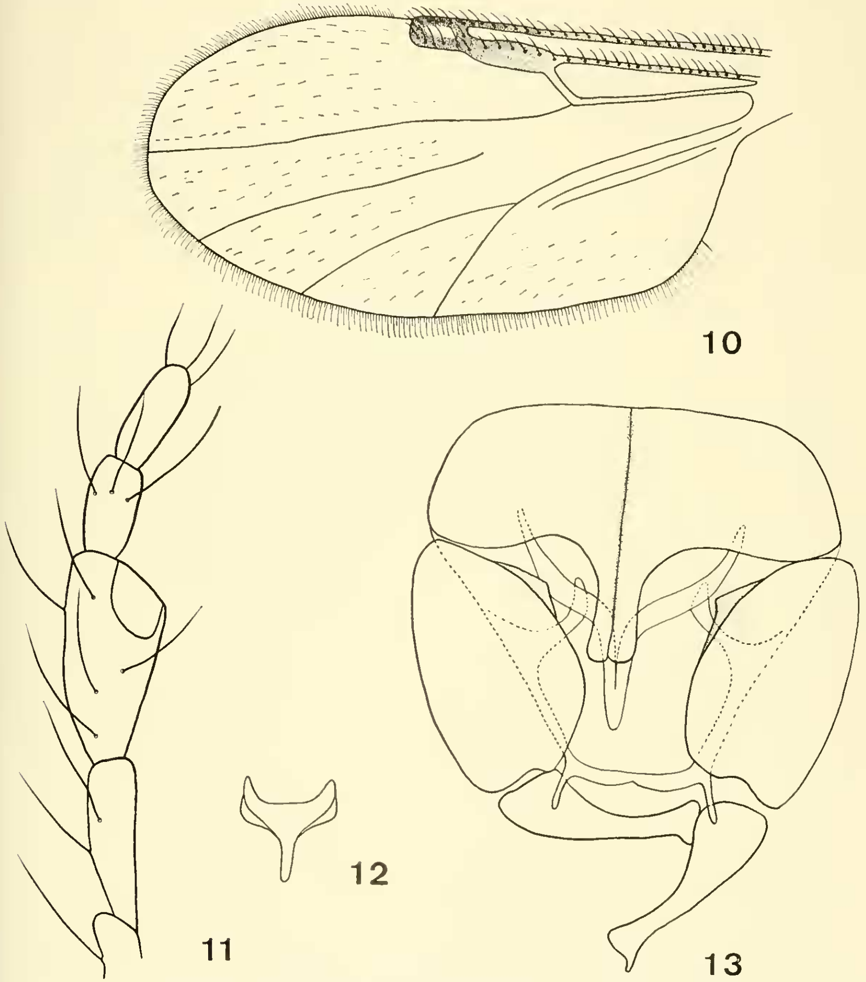
*Head:* Eye separation greater than diameter of a facet. Antenna with flagellomeres in proportion of 11:8:8:8:9:9:9:10:13:13:15:16:24; antennal ratio 1.03 (0.96-1.12; n=9); segments 9+10 to 11 in ratio of 0.67 (0.61-0.72; n=9); distal sensory tufts on segments 3, 5-10. Distal 4 palpal segments in proportion of 18:27:10:10; third palpal segment swollen, 2.11 (2.0-2.25; n=9) times as long as greatest breadth, with deep sensory pit (Fig. 11). Ratio of head length to proboscis 1.24 (1.10-1.46; n=8). Mandible with 11-13 (n=9) teeth.

*Thorax:* Legs yellowish brown; indistinct pale rings pre-apical on fore femora and subbasal on tibiae. Hind tibial comb with 4-5 spines.

*Wing:* (Fig. 10). Wing without pattern of pale and dark spots. Costa extending 0.54 (0.53-0.55; n=8) of entire wing length. Macrotrichia abundant.

*Abdomen:* Spermathecae unsclerotized.

MALE—Genitalia (Figs. 12, 13) with ninth sternum divided, with elongate mesal lobes extending posteriorly to almost same length as aedeagus. Ninth tergum tapering; caudal portion laterally convex, mesal notch present in some specimens, absent in others; apicolateral processes small, very slender. Basimere short, tapering slightly; ventral root well developed, slender with apically expanded end; dorsal root apparently consolidated into base of basimere; many large spines on mesal surface of basimere. Telomere swollen basally, narrowing distally with more or less blunt foot-shaped apex. Aedeagus composed of 2 slender sclerites, the basal or arm portions widely separated proximally, converging mesally, then turned caudad to form



FIGS. 10-13. *Culicoides hieroglyphicus* Malloch. Female: 10, wing; 11, palpus. Male: 12, claspettes; 13, genitalia, claspettes removed.

more or less parallel-sided median process. Claspettes fused to form modified triangular structure with long, slender caudomesal extension.

*DISTRIBUTION:* This species is a common western form occuring from South Dakota southward to Mexico and westward to California. New Mexico County Records: Bernalillo, Catron, Chaves, Colfax, DeBaca, Dona Ana, Eddy, Lincoln, Otero, Quay, Roosevelt, Sandoval, San Miguel, Santa Fe, and Sierra.

*VARIATION:* A large number of specimens collected near Glenwood, N. Mex., exhibited both male and female characteristics. These intersexes had normal male genitalia but possessed certain female head structures. The eyes were broadly contiguous, as one would expect in a male, but the third palpal segment was distinctly swollen with a deep sensory pit and many had denticulate mandibles. The most striking peculiarity were the antennae. These intersexes have the first eight antennal segments only slightly longer than wide and the transition between segment types occurs between segments 10 and 11. In a few specimens segment 11 was shortened. The pedicel, which is enlarged in normal males, apparently due to the presence of Johnstons organ, is reduced to the femalelike structure. A slightly reduced type of verticillate hairs occurs on these forms.

Downes (1958) has discussed a correlation between modification in head structures of males and mating behavior. *Culicoides utahensis* males, for instance, have femalelike antennae and palps, and this condition is apparently related to mating. Females of this species are often found in the ears of rabbits. The males, therefore, appear to be attracted to the rabbit, where they locate the females and mating occurs. A situation of this type is feasible for *hieroglyphicus* since females of this species are known to feed in the ears of rabbits in California. I do not know whether the high incidence of intersexes in this population represents a behavioral modification associated with mating or an extremely high infestation of mermithial nematodes, which also is known to induce the formation of intersexes.

*FEEDING HABITS:* Hoy (1966) has reported that in California this species attacks deer, feeding by day on the inner surfaces of the ears, and Jones (1965) found that it feeds on sheep in Colorado. These records, coupled with that of rabbits as hosts, indicate a rather broad host range for the species.

*DISCUSSION:* The difficulty of separating the *Selfia* species has been explained previously in the discussion of *brookmani*. The males of *heiroglyphicus* are readily separated from other species by the distinctive genitalia; however, with the possible exception of the mesonotal pattern, no clear-cut character is now known to distinguish the females from those of other *Selfia* species.

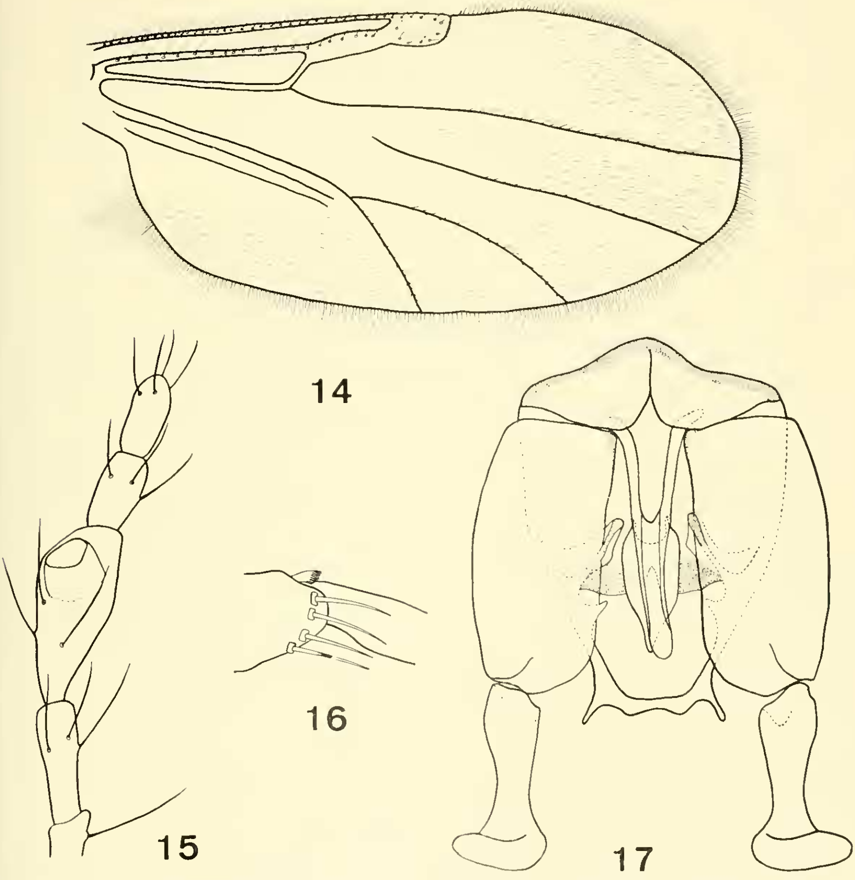
### 3. Culicoides (S.) jamesi Fox

(Figs. 14-17)

*Culicoides jamesi* Fox, 1946, Ent. Soc. Wash. Proc. 48:244 (male, female; Montana; fig. wing, mesonotal disc, palpus and male genitalia).

FEMALE—Length of wing 1.27 (1.20-1.39; n=15) mm.

*Head:* Eye separation equal or subequal to diameter of a facet. Antenna with flagellomeres in proportion of 14:11:10:10:11:12:12:13:15:17:17:18:25; antennal ratio 1.0 (0.94-1.13; n=16); distal sensory tufts present on segments 3-10; segments 9+10 to 11 in ratio of 0.63 (0.59-0.70; n=16). Distal 4 palpal segments in proportion of 16:27:8:13; third segment long and swollen, 2.26 (2.08-2.5; n=15) times as long as greatest breadth, with a deep sensory pit with many stalked sensillae lining proximal end (Fig. 15). Ratio



FIGS. 14-17. *Culicoides jamesi* Fox. Female: 14, wing; 15, palpus; 16, tibial comb. Male: 17, genitalia.

of length of head to proboscis 1.27 (1.20-1.39; n=15). Mandible with 11-13 (n=16) teeth.

*Thorax:* Legs brown. Hind tibial comb with 4 or 5 spines, in some specimens 4 on 1 tibia, 5 on the other (Fig. 16).

*Wing:* (Fig. 14). Wing without pattern of light and dark spots. Macrotrichia present in distal and posterior portions of wing. Costa extending to 0.56 (0.54-0.59; n=9) of distance to wing apex.

*Abdomen:* Spermathecae unsclerotized.

MALE—Genitalia (Fig. 17) with ninth sternum expanded mesally, very deep medial posterior cleft extending almost to base. Ninth tergum tapered with narrow, divergent apicolateral processes, mesal cleft poorly defined. Basimere long; ventral root small; dorsal root well developed and elongate; rugose membrane connecting basimere in area of dorsal root with lateral margin of the fused claspette. Telomere with large, distinctive, footlike apical expansion; apex turned at right angle to remainder of telomere. Aedeagus very long and slender with high rounded basal arch; aedeagal arms long, extending anteriorly almost parallel, with bases turned antero-laterally. Claspettes fused to form a posteriorly pointed plate-like structure; anterior arms curved mesally and slightly laterad to give an almost semi-circular anteromedial emargination.

*DISTRIBUTION: Culicoides jamesi* is a western species occurring from New Mexico to Montana, westward to California. New Mexico County Records: Catron, Lincoln, Grant and Sandoval.

*DISCUSSION:* For distinguishing features see the discussion of *brookmani.*

## Subgenus *CULICOIDES* Latreille 1809:251

Type species *Culex pulicaris* Linneaus as *Ceratopogon punctatus* Meigen (monobasic).

Large species with the apical portion of the second radial cell ending in a pale spot. Cell $M_4$ is dark at the base of the mediocubital fork, and the apices of veins $M_1$, $M_2$, $M_{3+4}$ and $Cu_1$ are dark.

The North American species of this subgenus belong to the *cockerellii* group.

### 4. **Culicoides (C.) cockerellii** (Coquillett)

(Figs. 18-22)

*Ceratopogon cockerellii* Coquillett, 1901, U.S. Natl. Mus. Proc. 23:603.
*Culicoides cockerellii* Coquillett; Kieffer, 1906, Gen. Insectorum, fasc. 42:54.

FEMALE—Length of wing 1.84 (1.61-2.04; n= 5) mm.

*Head:* Eyes contiguous, meeting only at a point. Antenna with flagellomeres in proportion of 16:13:15:15:15:15:15:15:21:23:27:30:36; antennal ratio 1.07 (1.03-1.10; n=5); segments 9+10 to 11 in ratio of 0.71 (0.68-0.75;

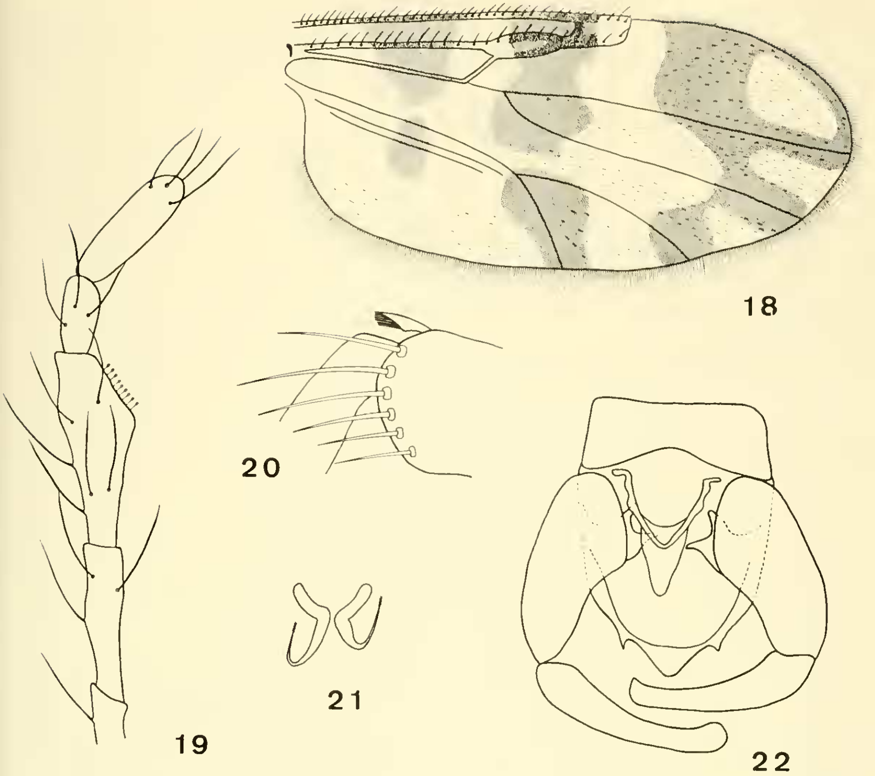


FIG. 18-22. *Culicoides cockerellii* (Coquillett). Female: 18, wing; 19, palpus; 20, tibial comb. Male: 21, claspettes; 22, genitalia, claspettes removed.

n=5); distal sensory tufts on segments 3, 5, 7, 9-15, occasionally absent from 10 or from 7, 9 and 10 (see discussion). Distal 4 palpal segments in proportion of 26:36:13:18; third palpal segment very slender and lacks a pit (Fig. 19), 3.26 (2.7-3.8; n=5) times as long as greatest breadth, possessing numerous stalked sensillae. Ratio of head length to proboscis 1.05 (0.84-1.20; n=4). Mandible with 14-16 (n=5) teeth.

*Thorax:* Legs dark brown. Hind tibial comb with 6 spines (Fig. 20).

*Wing:* (Fig. 18). Distal half of second radial cell in a light area; wing with 3 transverse bands: first band lying between r-m crossvein and base of wing, extending posteriorly from costa to beyond vein $M_{1+2}$, interrupted by pale area which extends to slightly anterior of $Cu_1$, another dark spot over $Cu_1$, $Cu_2$, and 1st V and extending slightly into vannal cell, majority of vannal cell in pale area; second dark band arising midway between r-m crossvein and distal end of second radial cell, extending to just behind $M_1$-$M_2$ fork, there interrupted by a light area, dark area in proximity of medio-cubital fork where it follows vein $Cu_1$ to margin; third dark band distal to poststigmatic spot, band very intense in anterior portion of wing. Macrotrichia long, rather dense in distal and posterior parts of wing. Costa extending 0.60 (0.54-0.62; n=5) of entire wing length.

*Abdomen:* Two oval spermathecae (crumpled in New Mexico specimens seen); ducts sclerotized at base; rudimentary spermatheca and ring present. MALE—Genitalia (Figs. 21, 22) with ninth sternum broad, with shallow caudomedian excavation. Ninth tergum tapering posteriorly, with distinct, rounded, caudal lobe; apicolateral processes very small. Basimere narrowing apically; roots small, subequal, tapering apically. Telomere large, gradually tapering to slightly expanded apex. Median posterior process of aedeagus broadly rounded apically, aedeagal arms slender, with slight swellings on lateral margins, basal portions turned laterally to give foot-shaped structure; lateral membraneous extensions extending from arms to lateral portion of median posterior process; basal arch rounded. Claspette with antero-laterally directed bases; stem swollen proximally, tapering to very slender anteriorly directed apex bearing fine fringe of subapical spines.

*DISTRIBUTION:* This species has previously been recorded from Alaska southward to California and Colorado. This is the first record of it from New Mexico. New Mexico County Records: Poorly marked form—Colfax, San Juan and Lincoln; well-marked form—Taos.

*VARIATION:* Wirth (1952), in discussing the *cockerellii* group in California, lists three varieties or forms in addition to *cockerellii sensu stricto.* Of the seven females of *cockerellii* taken during this investigation, four can readily be assigned to *cockerellii s. str.* as defined by Wirth, while the remainder had a reduced wing pattern and different sensorial configuration and closely agreed with the description of Wirth's variety "C." The culmination in reduction of wing pattern is exhibited by a specimen from San Juan River, San Juan Co., in which the wing pattern is reduced to the usual spot over the r-m crossvein, poststigmatic spot and two other very small round spots, one in the middle of cell $M_4$ and one lying just below the 1st vannal vein in the vannal cell. The poorly marked form has a sensorial pattern of 3, (5), 7, (9), (10), 11-15 as opposed to 3, 11-15 for the well-marked form. Since no males of *cockerellii* were taken during this study, information as to variation in the male genitalia is not available.

*DISCUSSION:* Vargas (1960) proposed the new subgenus *Anilomyia* for the *covagarciai* group, in which he includes *cockerellii* and *luteovenus* Root and Hoffman, as well as the neotropical species *rostratus* Wirth and Blanton. The *covagarciai* group as originally outlined by Wirth and Blanton (1959) did not include *luteovenus,* which was placed in the *pulicaris* group. There appears to be little gained by dividing this rather homogeneous group of species, previously known as the subgenus *Culicoides,* into two subgenera.

## Subgenus *AVARITIA* Fox, 1955:218

Type species *Ceratopogon obsoletus* Meigen (orig. des.).

This subgenus is composed of a group of small species with poorly marked wings. The distal portion of the second radial cell is in a pale spot, and macrotrichia are usually sparse. Antennal sensoria are located on segments 3 and 11-15, and the eyes of the females are contiguous. There are two subequal spermathecae with very short necks, and the hind tibial comb possesses 5 spines. The ninth tergum of the male genitalia usually lacks the mesal notch, the apicolateral processes are absent (except in *chiopterus*, in which they are poorly developed, blunt structures), the claspettes are separate and taper distally to a fine point which may or may not possess apical hairs, and the basimere has long, simple, subequal roots.

The members of this subgenus are widespread, two species occurring in the Palearctic and Nearctic regions, while a third species is Nearctic and Neotropical. One species, *obsoletus* (Meigen) occurs in New Mexico.

### 5. Culicoides (A.) obsoletus (Meigen)

(Figs. 23-27)

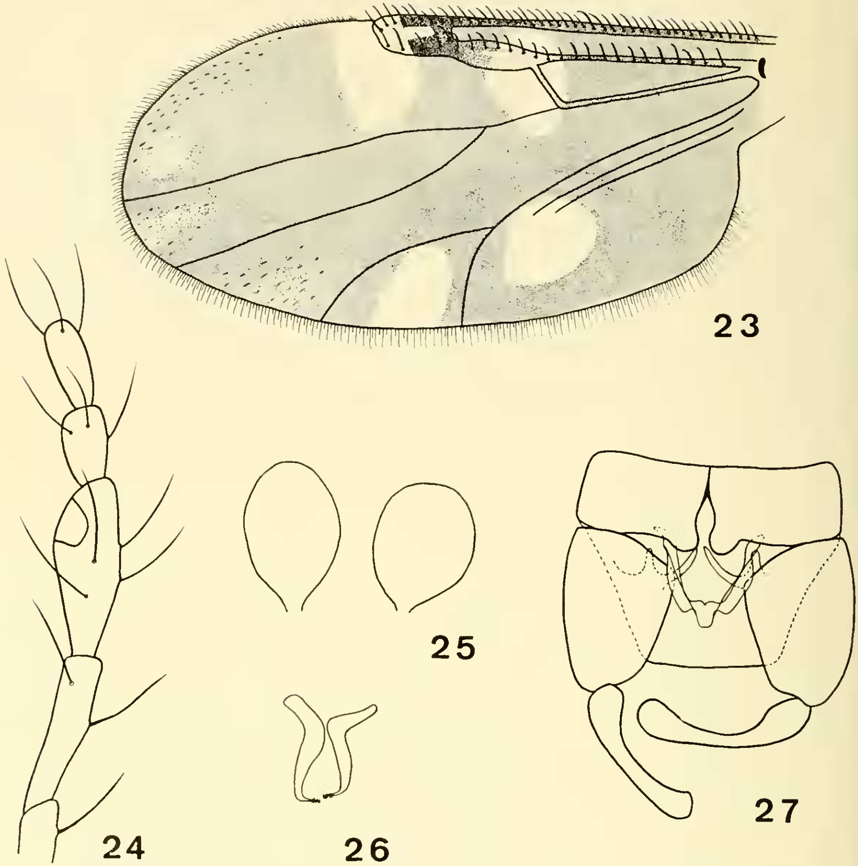
*Ceratopogon obsoletus* Meigen, 1818, Syst. Beschr. Gur. Zweifl. Ins., 1:76.
*Culicoides obsoletus* (Meigen); Goetghebeur, 1921, Mem. Mus. Roy. Hist. Nat. Belg., 8:180.
For additional synonomy see Fox (1955).

FEMALE—Length of wing 1.19 (1.01-1.36; n=9) mm.

*Head:* Eyes broadly contiguous. Antenna with flagellomeres in proportion of 11:10:10:10:11:11:12:13:17:17:17:18:30; antennal ratio 1.14 (1.0-1.23; n=9); segments 9+10 to 11 in ratio of 0.72 (0.65-0.79; n=9); distal sensory tufts on segments 3, 11-15. Distal four palpal segments in proportion of 17:18:8:10; third segment very slender, only slightly swollen (Fig. 24), 2.74 (1.8-3.7; n=7) times as long as greatest breadth (the specimen measuring 1.8 had an extremely short and slender third segment, hence the very small value); shallow sensory pore. Ratio of head length to proboscis 1.0 (0.87-1.24; n=6). Mandible with 12-16 (n=6) teeth.

*Thorax:* Legs brown; lacking distinct banding pattern. Hind tibial comb with 5 spines, one nearest spur usually longest.

*Wing:* (Fig. 23). Pattern indistinct and variable; apical half of second radial cell in a pale area; pale spot over r-m crossvein small, extending posteriorly beyond vein $M_{1+2}$, not attaining anterior wing margin; post-stigmatic spot rather elongate, extending to just anterior of vein $M_1$; rather vague pale spots in distal portion of cells $R_5$, $M_1$ and $M_2$, their position and intensity variable; pale spot in cell $M_4$ extending to posterior wing margin; small spot in anterior portion of vannal cell; poorly defined pale area in medial portion of wing. Costa extending 0.60 (0.57-0.63; n=9) of entire wing length. Macrotrichia sparse.



FIGS. 23-27. *Culicoides obsoletus* (Meigen). Female: 23, wing; 24, palpus; 25, spermathecae. Male: 26, claspettes; 27, genitalia, claspettes removed.

*Abdomen:* Two slightly unequal spermathecae (Fig. 25) 56 x 33 and 46 x 40 $\mu$, ducts sclerotized for a short distance; rudimentary spermatheca and ring present.

MALE—Genitalia (Figs. 26, 27) with ninth sternum broad; caudomedian excavation narrow, deep, anteriorly pointed; posterior lips of excavation distinctly lobe-like. Ninth tergum lacking apicolateral processes and mesal notch. Basimere with very long slender, pointed ventral roots; dorsal roots much shorter. Telomere only slightly swollen basally, mesal portion narrow, apex swollen, club-like. Aedeagus with short, sub-conical median posterior process; aedeagal arms with small, laterally directed bases, slightly sinuate posteriorly, abruptly bent mesally to form median process; basal arch very long, extending approximately 0.75 of entire length of aedeagus. Claspettes with very stout basilateral arms; stems swollen proximally, tapering to very slender apex bearing microscopic fringe of spines.

*DISTRIBUTION:* A very widespread species reported by Jamnback and Wirth (1960) as occurring in Eurasia, North Africa and North America. In North America *obsoletus* has been previously reported throughout the eastern United States and westward to include Colorado, Oklahoma and California. Canadian records include Alberta and British Columbia. New Mexico County Records: Lincoln, Otero.

*VARIATION:* The specimens from New Mexico designated in this paper as *obsoletus* do not completely agree with the species descriptions from the eastern United States. The most obvious discrepancy occurs in the male genitalia. There are apical hairs on the claspettes, as in typical *obsoletus,* and the mesal notch on the ninth sternum agrees closely with that species. The aedeagus, however, has a shape closely approximating that of *sanguisuga* (Coquillett). Because of the paucity of male specimens of this form from New Mexico, I have refrained from describing it as new. The *obsoletus* complex in the western United States is very poorly understood and is in need of extensive study, such as given the eastern spcies by Jamnback and Wirth (1960).

*FEEDING HABITS:* In many areas *obsoletus* constitutes a serious pest. Wirth (1952) has cited its annoyance in the mountains of the western states. Although various authors have described this species as pestiferous in the eastern states, Jamnback and Wirth (1960) state that many of these biting records actually refer to *sanguisuga.*

During this investigation, this species was collected biting man in the mountains of southern New Mexico. It appears to be crepuscular in its activity, as all specimens were taken at dusk.

## Subgenus *BELTRANMYIA* Vargas, 1953:34

Types species, *crepuscularis* Malloch (orig. des.).

This subgenus contains species in which the females possess one spermatheca and the antennal sensorial configuration varies from 3-15 to a very reduced condition in some species in which sensoria are present only on the third and various of the distal 5 segments. The wing has the second radial cell in a dark area, and the pattern of pale and dark spots may be either faint or well defined. The ventral root of the basimere in the male is either very reduced or absent. The claspettes are separate, tapering to very fine, pointed, unadorned apices.

Numerous representatives of this subgenus are found in the eastern United States; however, the distributions of three continue into the western states: *bermudensis* Williams as far west as Texas, *wisconsinensis* Jones to California and Washington, and *crepuscularis* Malloch to California.

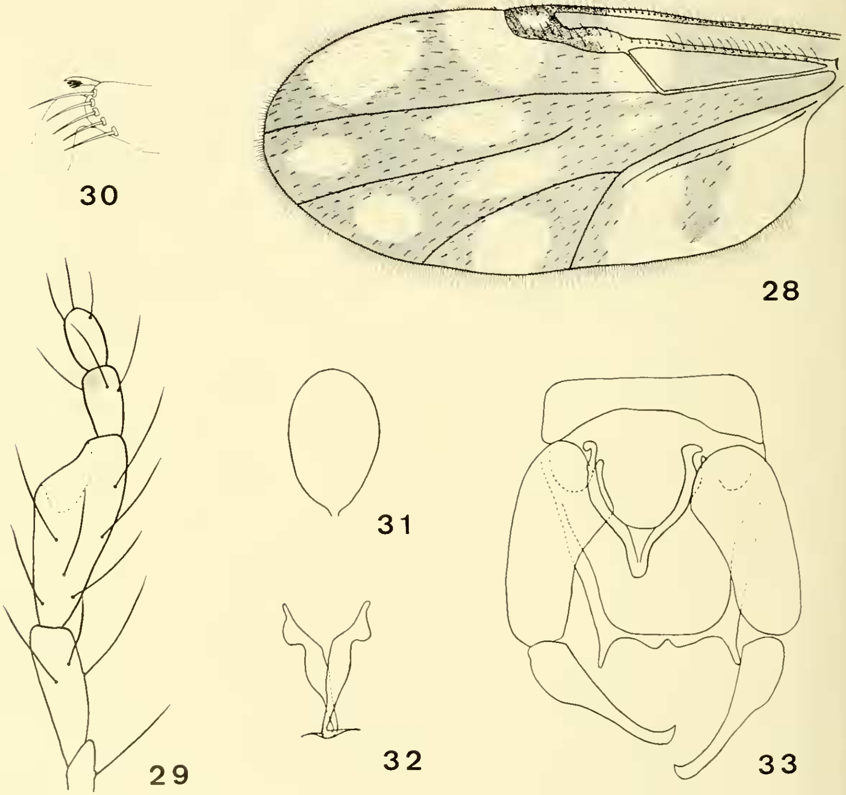
### 6. **Culicoides (B.) crepuscularis** Malloch

(Figs. 28-33)

*Culicoides crepuscularis* Malloch, 1915, Ill. State Lab. Nat. Hist. Bull. 10:303 (male, female; Illinois; fig. wing, mesonotal disc).

FEMALE—Length of wing 1.41 (1.14-1.56; n=22) mm.

*Head:* Eye separation about equal to diameter of a facet. Antenna with flagellomeres in proportion of 15:10:10:10:10:10:11:13:20:22:24:24:33; antennal ratio 1.35 (1.26-1.50; n=22); distal sensory tufts present on segments 3-14 (15), occasionally absent from segments 10 and 11; segments 9+10 to 11 in ratio of 0.90 (0.79-1.05; n=12). Distal 4 palpal segments in proportion of 20:33:11:13; third palpal segment swollen, 2.27 (2.0-2.56; n=25) times as long as greatest breadth, sensory pit deep with numerous stalked sensillae located on inner surface of pit (Fig. 29). Ratio of head length to proboscis 1.05 (0.95-1.14; n=23). Mandible with 14 (10-16; n=26) teeth.



FIGS. 28-33. *Culicoides crepuscularis* Malloch. Female: 28, wing; 29, palpus; 30, tibial comb; 31, spermatheca. Male: 32, claspettes; 33, genitalia, claspettes removed.

*Thorax:* Legs brown; fore femora with pre-apical pale ring, all tibiae with subbasal pale rings. Hind tibial comb with 4 spines (Fig. 30).

*Wing:* (Fig. 28). Second radial cell in a dark area; pale spot over r-m crossvein extending slightly posteriorly to vein $M_{1+2}$ but not extending to anterior margin; remaining pale spots located as follows: immediately distal to second radial cell, in distal portion of cell $R_5$ but not attaining wing margin, in cells $M_1$, $M_2$, $M_4$; a double spot in distal portion of vannal cell, usually attaining the wing margin; two elongate spots in proximal portion of cells $M_1$ and $M_2$; medio-cubital fork in a dark area. Macrotrichia abundant over surface of the wing. Costa extending to 0.56 (0.51-0.64; n=22) of entire length of wing.

*Abdomen:* One large spermatheca (Fig. 31) with neck sclerotized for a very short distance. Rudimentary spermatheca, without sclerotized ring, occasionally evident in slide-mounted preparations.

MALE—Genitalia (Figs. 32, 33) with narrow ninth sternum, caudiomedial excavation, broad, deep; membrane spiculate. Ninth tergum tapering posteriorly, with prominent apicolateral processes. Basimere long and slender, dorsal root well developed, ventral root absent. Telomere expanded basally, tapering, with a slightly swollen, mesally tipped apex. Aedeagus with conical, distally truncate, median posterior process; aedeagal arms long and slender with small laterally directed bases, basal arch rounded. Claspettes with pronounced foot-shaped basal expansions; mesal margins of stem straight, lateral margins swollen at approximate mid-point, stems sharply bent at apex to form simple, ventrolaterally directed tips.

*DISTRIBUTION:* This species has been taken in most states from New England to California, Mexico into Canada. New Mexico County Records: Catron, Colfax, Dona Ana, Lea, Lincoln, Otero, Quay, Rio Arriba, Sandoval, San Juan, San Miguel and Socorro.

*VARIATION:* Considerable variation exists in the wing pattern of this species at several localities. In Rio Arriba County, poorly marked forms were taken that exhibited reduction in number and size of the distal wing spots. Some of these specimens lacked the pale spots in cell $M_1$, and the spots in cells $R_5$, $M_2$ and $M_4$ were greatly reduced. In other specimens pale spots were absent in these four cells. Dr. Willis Wirth (in litt.) informs me that this variation in wing markings as well as some additional characters appears to show regional trends. Together with other morphological and biological descrepancies reported by various authors, it suggests that there may be more than one species disguised under the name *crepuscularis.*

Two intersexes were taken at light, along with numerous normal specimens, at the Bosque del Apache Refuge along the Rio Grande.

*DISCUSSION:* Although the wing markings of *crepuscularis* superficially resemble the wing pattern of females of certain other New Mexico species, the presence of one large spermatheca will readily distinguish this species. Only two other New Mexico species, *reevesi* and *variipennis,* have a single spermatheca. Separation of the females of these three species is accomplished easily by the irregular wing markings, sensorial pattern and usual "C" shaped spermatheca of *variipennis* and the unusual shape of the antennal segments, sensorial pattern, etc., of *reevesi.*

This species is not closely allied to any of the other New Mexico species, but is very similar to several, particularly *hollensis* (Melander and Brues) and *wisconsinensis* Jones, which occur primarily in the eastern portion of the U.S.

*FEEDING HABITS:* With the exception of a reference by Edmunds and Keener (1954), in which they state that *C. crepuscularis* is a very severe pest in Nebraska, the proponderence of evidence accumulated for this species indicates an ornithophilic behavior. This is supported by reports of Williams (1955) and Snow (1955) that *crepuscularis* is active in considerable numbers in the forest canopy; and Messersmith (1965) has taken large numbers of engorged females of the species from chicken houses.

The importance of *crepuscularis* in the interrelationship between various pathogens and their avian hosts has recently been stressed. Robinson (1961) cited the development of an avian filarial worm in this species after having fed on an infested starling, while Bennett (1961) used *crepuscularis,* along with other species, in trypanosome transmission experiments involving several species of birds. Fallis and Bennett (1961) reported developing oöcysts and sporozoites of *Haemoproteus* in the gut wall of *crepuscularis* after the flies had fed on infected crows and purple finches.

## Subgenus *MONOCULICOIDES* Khalaf, 1954:39

Type species *Ceratopogon nubeculosus* Meigen (orig. des.).

Large species with second radial cell in dark area and with moderately abundant macrotrichia. The eyes are widely separated, and one C-shaped spermatheca is present. The ninth tergum of the male has well developed apicolateral processes, the claspettes are fused basally, with the apices terminating in slender separate points, and the basimere possesses a moderately long ventral root, but a very short dorsal root.

Two species, *gigas* Root and Hoffman and *variipennis* (Coquillett), are included in the Nearctic fauna, although only *variipennis* is found within the boundaries of the United States.

### 7. **Culicoides (M.) variipennis sonorensis** Wirth and Jones

(Figs. 34-39)

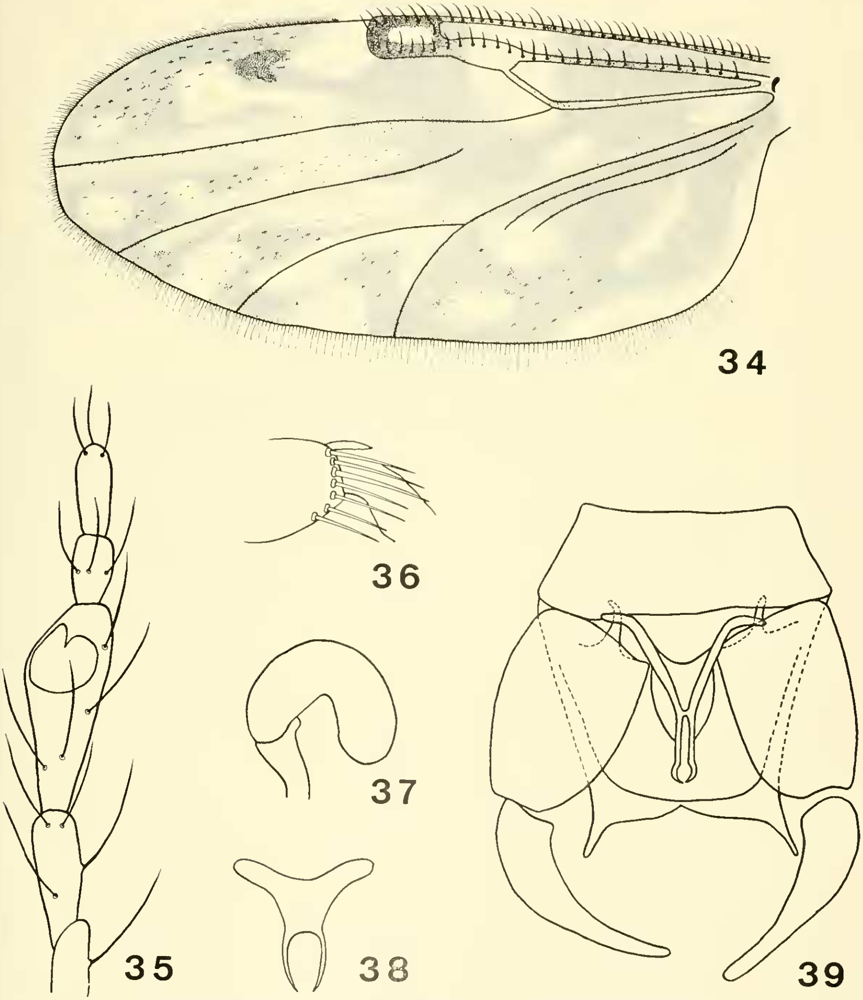
*Ceratopogon variipennis* Coquillett, 1901, U.S. Nat. Mus. Proc. 23:602.
*Culicoides variipennis;* Kieffer, 1906, Gen. Insectorum, fasc. 42:55.

*Culicoides variipennis sonorensis* Wirth and Jones, 1957, U. S. D. A. Tech. Bull. no. 1170, p. 18-20 (male, female; Arizona; fig. wing, spermatheca, mesonotal disc, palpus, male genitalia).

*Culicoides variipennis australis* Wirth and Jones, 1957, U. S. D. A. Tech. Bull. no. 1170, p. 15-17 (male, female; Louisiana; fig. wing, spermatheca, mesonotal disc, palpus, antenna). NEW SYNONOMY.

FEMALE—Length of wing 1.55 (1.30-1.79; n=14) mm.

*Head:* Eyes widely separated by much more than diameter of a facet. Antenna with flagellomeres in proportion of 13:13:13:13:13:13:13:14:16:17: 18:18:26; antennal ratio 0.86 (0.79-0.90; n=13); segments 9+10 to 11 in ratio of 0.59 (0.54-0.70; n=7); distal sensory tufts always on segments 3, 8-10,



FIGS. 34-39. *Culicoides variipennis sonorensis* Wirth and Jones. Female: 34, wing; 35, palpus; 36, tibial comb; 37, spermatheca. Male: 38, claspettes; 39, genitalia, claspettes removed,

often on 5, 6 or 7, occasionally present on segment 4. Distal 4 palpal segments in proportion of 25:35:10:15; third palpal segment very swollen (Fig. 35), 2.38 (2.11-2.69; n=14) times as long as greatest breadth, with moderately deep sensory pore. Ratio of length of head to proboscis 1.10 (1.02-1.17; n=10). Mandible with 11-15 (n=14) teeth.

*Thorax:* Legs brown; fore femora with median pale band; all femora with pre-apical pale ring, tibiae with subbasal pale rings. Hind tibial comb with 6-7 spines (Fig. 36).

*Wing:* (Fig. 34). Second radial cell in a very dark spot; pattern of pale and dark spots irregular. Costa extending 0.55 (0.53-0.58; n=14) of entire wing length. Macrotrichia short, rather sparse.

*Abdomen:* One large, mesally bent, C-shaped spermatheca (Fig. 37).

MALE—Genitalia (Figs. 38, 39) with ninth sternum having little if any posterior excavation. Ninth tergum with prominent, triangular apicolateral processes. Basimere short, slightly tapered; ventral root small; dorsal root long, slightly curved laterally. Telomere curved, strongly swollen basally, abruptly narrowing approximately at mid-length, distal half gradually tapering to simple apex. Aedeagus elongate; median posterior process consisting of two narrow separate points with slight sub-apical expansion, lateral portion of median process membraneous; aedeagal arms short, gently curved laterally; basal arch short, rounded, extending only about 0.25 of entire length of aedeagus; membrane posterior to basal arch may or may not be spiculate. Claspettes fused basally, with slender, pointed, separate apices.

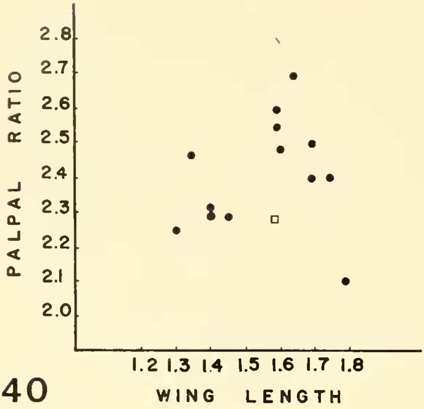
*DISTRIBUTION:* This subspecies of a widely distributed form found in the United States, Canada, Mexico and Baja California is limited to the more arid portions of the southwestern United States and Mexico. Wirth and Jones (1957) reported *sonorensis* from Arizona, California, Nevada, New Mexico, Oklahoma, Utah, Washington and Mexico, and under the name *australis* it has been recorded in Kansas, Louisiana, Missouri, Oklahoma, South Carolina, Texas and Virginia. It is probably the most common species occurring in New Mexico. New Mexico County Records: Chaves, Curry, DeBaca, Dona Ana, Eddy, Lea, Lincoln, Quay and Roosevelt.

*DISCUSSION:* Wirth and Jones (1957) proposed five subspecies for polytypic *Culicoides variipennis*. Consideration of the distributional data, ecological associations, as well as the critical examination of a number of specimens from various localities in New Mexico make evident the need for a discussion of the validity of certain aspects of this division.

Many times when attempting to analyze a taxonomic problem, it is desirable to define the taxonomic category under investigation. The *variipennis* situation is complicated by the omission of, or reference to, such an explanation of what these writers consider to be a subspecies. If we take one of the more widely used definitions of subspecies, i.e., "an aggregate of local populations of a species inhabiting a geographic subdivision of the range of the species and differing taxonomically from other populations of the species (Mayr 1963)," and apply it to the *variipennis* problem, several discrepancies become evident.

There can be little doubt that *variipennis sensu lato* is divisible into two forms. On the basis of morphological and particularly biological evidence, it would appear that *variipennis variipennis* and *variipennis sonorensis* are worthy of at least subspecific status. The former subspecies is restricted to the forested northern and eastern portions of North America and is not associated with saline environments. It is considered by Ross (1962) to be the oldest and most stable form. The *sonorensis* stock of the southwestern, arid portion of North America has been further divided into four subspecies on the basis of biological as well as morphological criteria. The *australis* form is typically found in saline environments and is characterized by Wirth and Jones as having long wings, more slender palps, higher number of antennal sensoria and a bare aedeagus (see Table 2 for numerical values). The *sonorensis* form typically inhabits polluted waters and is distinguished by shorter wings, stouter palps, lower number of supernumerary antennal sensoria and a spinose aedeagus (Table 2). As will be shown below, this habitat isolation apparently breaks down in southeastern New Mexico, and populations occur that exhibit all morphological intergradation between *sonorensis* and *australis*. No definite statement can be made regarding *occidentalis*, the west coast subspecies, or *albertensis*, which occurs in the Midwest, northward into Canada. These two forms lie outside the scope of this investigation; however, it should be noted that Wirth and Jones state that over much of its range the latter form cannot be distinguished from other forms of the *sonorensis* stock. Ross (1962) considers *occidentalis* to be the oldest and most stable form of the *sonorensis* stock; however, this is open to serious question.

A sample from the Pecos River, east of Roswell, provided an excellent opportunity to examine the extent of infraspecific variation in a given *variipennis* population. The range of variation among 28 specimens examined from this locality included individuals that could definitely be assigned to the typical *sonorensis* form to those that exhibited all the characteristics of *australis*. Of 14 males, 4 had very spinose aedeagi of the *sonorensis* form, 8 possessed bare aedeagi of the *australis* form and 2 specimens could be considered as intermediate in that they had only 5 or 6 spines. Among the females (Figs. 40, 41), 5 specimens having short wings, swollen palpi and 1 or 2 additional sensoria could be assigned to the *sonorensis* form. Eight of the remaining females could be designated as *australis*, although some resembled *sonorensis* in 1 or 2 characters. One female appeared to be intermediate (shown in scatter diagram by an open



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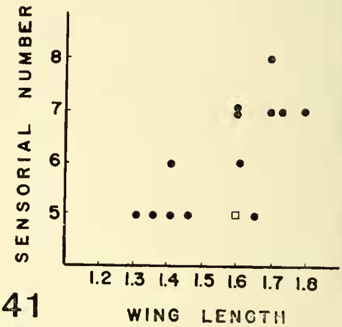

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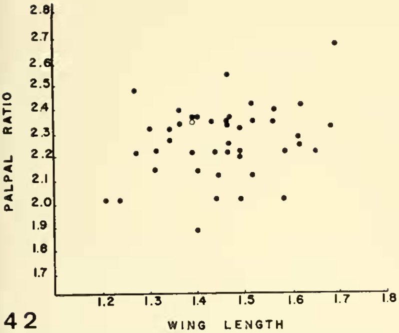
FIGS. 40-41. Scatter diagrams showing extent of intraspecific variation in a given population (Pecos River, east of Roswell, New Mexico) of *Culicoides variipennis.* Open square indicates apparent intermediate form between *C. variipennis australis* and *C. variipennis sonorensis* forms.

rectangle, having a long wing (1.58 mm.), one supernumerary sensoria and a very swollen palp (P.R.=2.23).

Genetically, a given local population can, if it occurs in a zone of intergradation, contain elements of more than one subspecies. If the zones of contact or overlap between subspecies have not been determined, however, or if the local population in question is remote from such a zone, the population should taxonomically be assigned to only one or another subspecies. That is, subspecies are generally thought of as being for the most part mutually exclusive.

The evidence described would imply that either *australis* is only an infrasubspecific form of *sonorensis*, or that the four characters Wirth and Jones used to differentiate supposed subspecific populations will not effectively do so. (A fifth character, the number of mandibular teeth of the females, is not included here because of the high degree of overlap that exists between the two forms).

One remaining criterion for subspecific distinction of these two forms is habitat isolation. A large number of specimens were examined from a salt lake near Loving, New Mexico. The extreme salinity of this habitat was evidenced by a salt crust at various places along the margin. Potash was mined nearby. Over 50 specimens were examined from this locality, and only one form was present (Figs. 42, 43), but these were not *australis,* as one would expect, but *sonorensis*! All the males examined had spinose aedeagi, and the number of antennal sensoria and palpal ratio of the females were almost precisely those given by Wirth and Jones as mean values for *sonorensis*. The mean wing length of this series was somewhat greater than would be expected for a *sonorensis* population; however, the agreement



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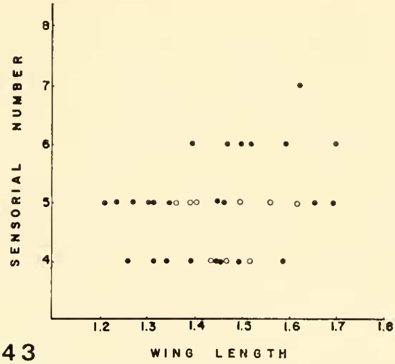

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Figs. 42-43. Scatter diagrams showing extent of intraspecific variation in a given population (Salt Lake, near Loving, New Mexico) of *Culicoides variipennis*. Open circles indicate more than one individual exhibiting these character states.

in the other characters would definitely suggest that this is a population of *sonorensis*. Here again the range of such characters as wing length and palpal ratio encompassed almost the entire range of variation Wirth and Jones established as 95% limits of both subspecies.

If *australis* and *sonorensis* were actually subspecies, the long wing characteristic of the Loving population could be due to gene flow between them. Subspecific intergradation cannot account for the remaining ecological and morphological discrepancies, however, and the spinose aedeagi, low number of supernumerary sensoria and palpal ratio indicate that this population is definitely *sonorensis*.

The wide variation of characters found in the Pecos River sample might be ascribed to a zone of contact or overlap between two phenotypically distinct, allopatric populations. If these phenotypically different populations are considered as subspecies, i.e., *australis* and *sonorensis*, intergradation between them should not occur also at such distant localities as northern Oklahoma and southern Texas (cited by Wirth and Jones) and southern New Mexico, especially when both subspecies are shown to occur at various intermediate localities. The area enclosed by these sites of intergradation is almost half of the proposed range of *australis*.

Rowley (1965), in his study of the bloodsucking midges in the Columbia Basin of Washington, has also reported two subspecies of *variipennis*, i.e., *occidentalis* and *sonorensis*, occurring in the same area. In the Columbia Basin Crab Creek flows near numerous alkaline potholes producing, with regard to salinity, two distinct larval habitats in very close proximity. Each of these habitats is theoretically better suited for a different subspecies. If these two forms were subspecies of one species, they would be expected to become merged where they occur sympatrically. Rowley reports that individuals from this area, like those from the above mentioned localities in southeastern New Mexico, exhibit a great amount of variation in the characters used for subspecific designation by Wirth and Jones.

One possible explanation for the *variipennis* problem is that these forms of the *sonorensis* stock are ecotypes produced by the response of the immature stages to their particular environment. The relatively large amount of morphological variation that exists among *variipennis* populations, such as at the Washington and New Mexico localities, could therefore be attributed to selection by the habitat. The designation of ecotypes rather than subspecies would also clarify the many populations of *variipennis* in the western United States that are unassignable to "subspecies."

The preponderance of evidence accumulated in this investigation relating to *C. variipennis* would imply that, on the basis of the characters presented by Wirth and Jones, only one subspecies, *sonorensis,* occurs in New Mexico and that *australis* is only an infrasubspecific form of *sonorensis.* Accordingly, I consider *australis* a synonym of *sonorensis.*

*FEEDING HABITS: Culicoides variipennis sonorensis* is the most economically important species in the New Mexico fauna, due to its involvement with the transmission of bluetongue virus in sheep. Price and Hardy (1954) incriminated *C. variipennis* in the transmission of bluetongue virus when two sheep inoculated with macerated *variipennis* adults developed clinical bluetongue. Foster, Jones and McCrory (1963) obtained positive biological transmission of bluetongue in sheep when they allowed *variipennis* to feed on infected sheep and later on uninfected animals.

As shown above, this species fulfills one of the requirements of a vector in that it is capable of biological transmission of the bluetogue virus. Later investigations by Jones (1961, 1965) have shown that *sonorensis* will naturally approach sheep in the field in sufficient numbers, and during a major outbreak of bluetongue of sheep in Colorado, *sonorensis* was taken in large numbers by sheep baited traps.

TABLE 2. Summary of data regarding morphological variation of two populations of *Culicoides variipennis.*

| Subspecies of Wirth and Jones 1957 or New Mexico locality | Wing Length | | Palpal Ratio | | Additional Antennal Sensoria | | |
|---|---|---|---|---|---|---|---|
| | Mean | Range* | Mean | Range | Mean | Range | Aedeagus |
| *australis* | 1.54 | 1.39-1.69 | 2.53 | 2.19-2.87 | 2.75 | 0.93-4.00 | bare |
| *sonorensis* | 1.26 | 1.16-1.36 | 2.23 | 1.99-2.47 | 0.83 | 0-2.01 | spinose |
| Pecos River east of Roswell | 1.55 | 1.30-1.79 | 2.38 | 2.11-2.69 | 2.0 | 1-4 | bare to spinose |
| Salt Lake near Loving | 1.46 | 1.21-1.70 | 2.42 | 1.86-2.66 | 0.8 | 0-3 | spinose |

* Represents 95% limits or Wirth and Jones (1957) for *australis* and *sonorensis.*

Although *sonorensis* feeds on man, Jones (1959) has shown that it prefers cattle, sheep and man in a descending sequence. Under laboratory conditions it will engorge on chickens.

## Subgenus *DRYMODESMYIA* Vargas, 1960:40

Type species *copiosus* Root and Hoffman (orig. des.).

This subgenus contains species with hairy wings and more or less distinctly rounded pale spots. There is often a prominent pale spot lying on the basal portion of vein $M_1$ and usually a pale spot over the median portion of vein $M_2$. A distinct pale spot is usually present in cell $M_4$. The r-m crossvein is in a pale spot. The third palpal segment of the females is usually swollen with a deep sensory pit. Two sclerotized spermathecae, a rudimentary spermatheca and ring are present. The hind tibial comb has four spines. The male genitalia has the claspettes swollen basally with the basal portion anterio-laterally directed and usually knobbed. The stems are slender, lack lateral lobes and possess slender, simple and often turned, twisted or contorted apices. The basimere has simple roots and the aedeagus is usually broad with a low basal arch and stout basal arms.

### 8. **Culicoides (Dr.) sitiens** Wirth and Hubert

(Figs. 44-48)

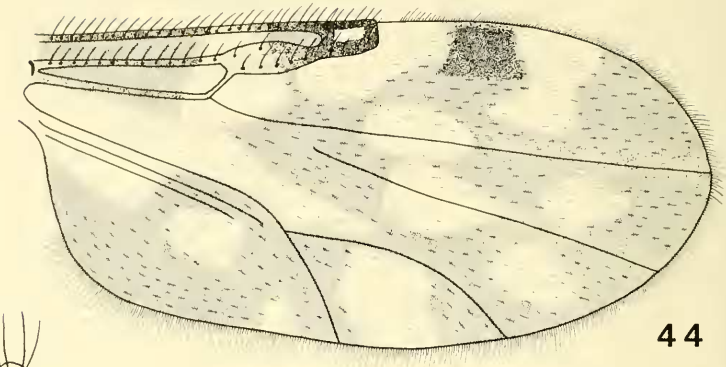
*Culicoides sitiens* Wirth and Hubert, 1960, Ent. Soc. Amer. Ann. 53:652 (male, female; California; fig. wing, palpus, spermathecae, male genitalia).

FEMALE—Length of wing 1.34 mm.

*Head:* Eyes separated by about half the diameter of a facet; inferior transocular suture present. Antenna with flagellomeres in proportion of 13:10:11:12:13:13:13:13:18:18:20:21:28; antennal ratio 1.07; distal sensory tufts present on segments 3-9, (10), 11-15; segments 9+10 to 11 in ratio of 0.69. Third palpal segment greatly swollen, 2.33 times as long as greatest breadth, with a deep slender sensory organ, opening by a small rounded opening (Fig. 45). Ratio of head length to proboscis 1.0. Mandible with 14 teeth.

*Thorax:* Legs with broad pre-apical pale rings on fore and midfemora, all tibiae with subbasal pale rings. Hind tibial comb with 4 spines (Fig. 46).

*Wing:* (Fig. 44). Second radial cell in a dark area; pale spot on r-m crossvein extending from costa posteriorly beyond vein $M_{1+2}$, uniting with elongate spot in extreme basal portion of cell $M_2$; poststigmatic spot curved proximally around second radial cell; mesally constricted pale spot located in median portion of cell $R_5$, extending from anterior wing margin to slightly before vein $M_1$; pale spots in distal portions of cells $M_1$ and $M_2$ not attaining wing margin; spot in cell $M_4$ broadly joining posterior margin of wing; 2 rounded spots in distal portion of vannal cell, posteriormost spot



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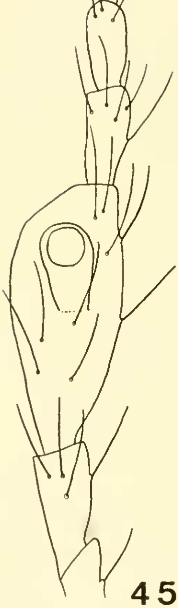

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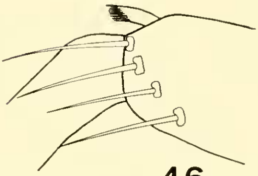

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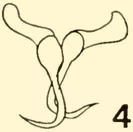

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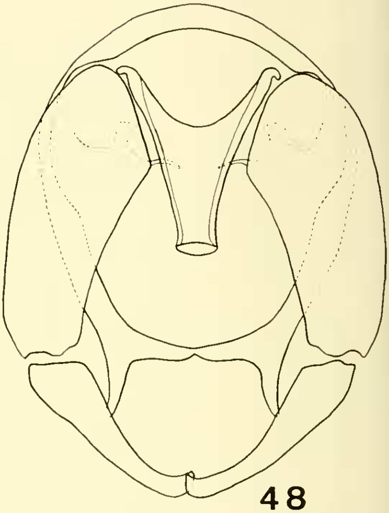

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FIGS. 44-48. *Culicoides sitiens* Wirth and Hubert. Female: 44, wing; 45, palpus; 46, tibial comb. Male: 47, claspettes; 48, genitalia, claspettes removed.

smallest; pale spots present on basal portions of veins $M_1$ and $M_2$, spot over vein $M_1$ barely below posterior border of poststigmatic spot; a small spot resting on anterior surface of medio-cubital fork. Macrotrichia abundant over entire surface of wing. Costa extending to 0.51 of entire length of wing.

*Abdomen:* Two unequal, subpyriform spermathecae present, both crumpled in only female specimen seen, ducts absent; rudimentary spermatheca and ring present.

MALE—Genitalia (Fig. 47, 48) with ninth sternum very narrow, with shallow caudomedian excavation. Ninth tergum with prominent, distally divergent, apicolateral processes. Basimere with very slender ventral root; dorsal root broad, truncate. Telomere tapering distally with a slightly curved, mesally tipped apex. Aedeagus stout, broad, conical, truncate median posterior process; aedeagal arms short with small upturned bases; basal arch gently curved, extending about 0.30 of total length of aedeagus. Claspettes with strong basolateral arm; stem swollen, diminishing basally to a very slender, laterally directed apex.

*DISTRIBUTION:* This is a southwestern species previously reported from Arizona, California and Baja California. New Mexico County Record: Sandoval.

*DISCUSSION:* This species has been described by Wirth and Hubert (1960) from the rotting parts of cacti, having been reared from *Opuntia* and *Lophocereus.*

### 9. **Culicoides (Dr.) byersi** new species

(Figs. 1, 49-54)

FEMALE—Length of wing 0.89 (0.88-0.91; n=2) mm.

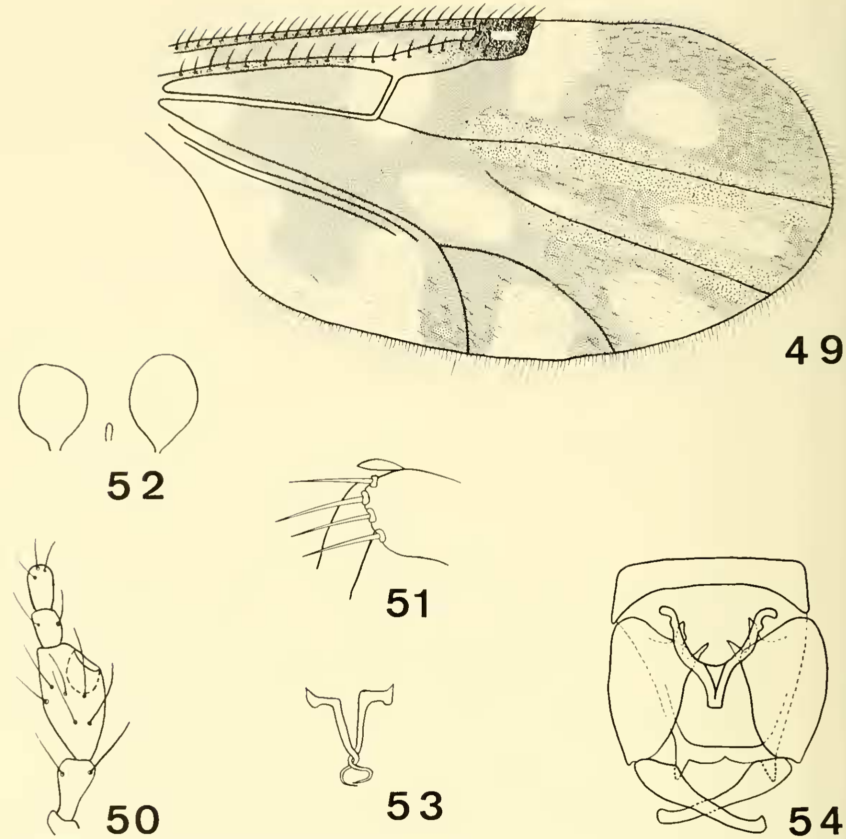
*Head:* Eyes barely separated to contiguous. Antenna with flagellomeres in proportion of 10:8:9:9:9:9:9:10:15:15:17:17:21; antennal ratio 1.13 (1.09-1.15; n=3); segments 9+10 to 11 in ratio of 0.73 (0.72-0.75; n=3); distal sensory tufts present on segments 3, 5, 7, 9, 11-15. Third palpal segment short, very swollen (Fig. 50), 1.7 (1.6-1.8; n=3) times as long as greatest breadth, with deep sensory pore. Ratio of head length to proboscis 1.67 (1.57-1.77; n=2). Mandible with 9-11 very small teeth.

*Thorax:* Legs dark brown; fore femora with pre-apical pale band, tibiae with subbasal pale band. Hind tibial comb with 4 spines (Fig. 51).

*Wing:* (Fig. 49). Second radial cell in a dark area; small round spot over r-m crossvein, barely extending beyond vein $M_{1+2}$; rather long, narrow poststigmatic spot; remaining spots as follows: small, round spot in median portion of cell $R_5$; pale spot in distal portion of cell $M_1$ not attaining wing margin; pale spots in distal portions of cells $M_2$ and $M_4$ may or may not extend to margin; a mesally constricted pale spot in distal portion of vannal cell attaining wing margin; a rather indefinite pale area anterior to mediocubital fork. Costa extending 0.54 of entire wing length. Macrotrichia usually confined to distal and posterior wing areas and veins.

*Abdomen:* Two subequal spermathecae (Fig. 52) 49 x 39 and 43 x 39 $\mu$, ducts sclerotized for a very short distance; rudimentary spermatheca present.

MALE—Genitalia (Figs. 53, 54) with ninth sternum with shallow caudomedian excavation. Ninth tergum with prominent, divergent apicolateral processes. Basimere with slender, simple, ventral root; dorsal root more or less truncate. Telomere tapering, with swollen, tipped apex. Aedeagus with truncate median posterior process, in allotype male slightly flared apically;



Figs. 49-54. *Culicoides byersi,* new species. Female: 49, wing; 50, palpus; 51, tibial comb; 52, spermathecae. Male: 53, claspettes; 54, genitalia, claspettes removed.

aedeagal arms arcuate, with knobbed, laterally directed bases, basal portion of stem with small lobe on lateral margin immediately distal to anterior bend of arms; basal arch curved. Claspette with stout basolateral arm; stem abruptly bent posteriorly, long, tapering to a very slender, contorted apex.

*DISTRIBUTION:* New Mexico (Catron Co.) and Arizona.

*Specimens examined:* Holotype female, Whitewater Forest Service Camp, 5 mi. E. of Glenwood, New Mexico, 24 June 1953, W. W. Wirth, at light. Allotype male, Glenwood Fish Hatchery, Glenwood, New Mexico, 2 Aug. 1965, W. R. Atchley, at light. Paratypes, 1 male, 1 female, same data as holotype; 1 female, Whitewater Forest Service Camp, 1 Aug. 1965, W. R. Atchley, at light. Additional specimens examined: 1 female, Mormon Lake, Coconina Co., Arizona, 8-15 July 1956, F. W. and F. G. Werner.

*DISCUSSION:* This species is very close to *hinmani* Khalaf and *borinqueni* Fox, tree-hole breeders of the *copiosus* group. *Culicoides byersi* can be distinguished from *hinmani* by the sensorial pattern and the presence of a single elongate pale spot immediately posterior to the second radial cell.

Both *hinmani* and *borinqueni* have two small spots immediately posterior to the second radial cell. The vannal cell of *byersi* has a large U-shaped spot broadly borderng the wing margin, whereas in *hinmani* the vannal cell is provided with two or three pale spots, the distalmost spot at best narrowly attaining the wing margin. *C. byersi* can be distinguished from *borinqueni* in that the combined length of antennal segments 9 and 10 is greater than 11; and the antennal ratio of *byersi* is 1.13 as opposed to approximately 1.7 of *borinqueni*.

I am very happy to name this species for my Major Professor at the University of Kansas, Dr. George W. Byers.

## Subgenus *DIPHAOMYIA* Vargas, 1960:40

Type species *baueri* Hoffman (orig. des.).

Vargas (1960) erected this subgenus for the *iriartei* group as defined by Wirth and Blanton (1959). The species of this subgenus have the second radial cell in a dark area and a pale spot over vein $M_2$. The hind tibial comb has 4 spines. Two spermathecae are present, each with a long sclerotized neck. The ventral root of the basimere is long, slender and curved, with a prominent posterior process. The claspette is knobbed basally, with an apical fringe of spines. There are distinct bladelike processes located on the postero-lateral margins of the basal arms of the aedeagus.

Two species of the subgenus, *baueri* and *hematopotus,* are found in the New Mexico fauna.

### 10. **Culicoides baueri** Hoffman

(Figs. 55-59)

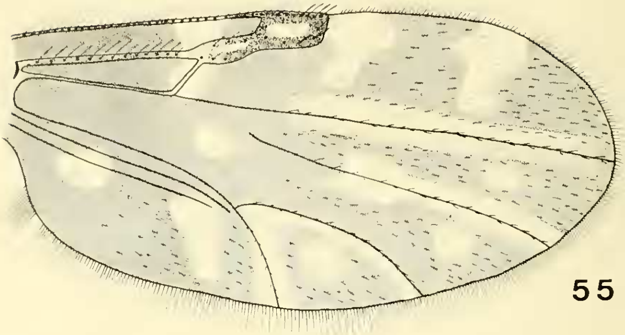
*Culicoides baueri* Hoffman, 1925, Amer. Jour. Hyg. 5:297 (male, female; Maryland; fig. wing, mesonotal disc).

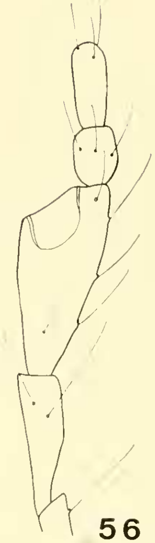
FEMALE—Length of wing 1.35 (1.19-1.40; n=10) mm.

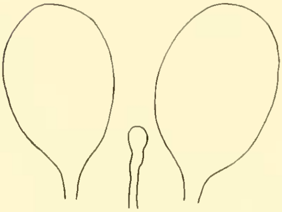
*Head:* Eyes separated less than diameter of a facet. Antenna with flagellomeres in proportion of 11:10:9:10:11:10:10:12:15:15:18:19:30; antennal ratio 1.07 (0.98-1.28; n=9), segments 9+10 to 11 in ratio of 0.66 (0.65-0.70; n=6); distal sensory tufts on segments 3, 5-10, occasionally present on segment 4 or absent from segment 5 and/or 6. Distal 4 palpal segments in proportion of 17:24:7:10; third palpal segment swollen, 2.17 (1.9-2.5; n=12) times as long as greatest breadth (Fig. 56). Ratio of head length to proboscis 1.24 (1.0-1.44; n=9). Mandible with 10-12 (n=9) teeth.

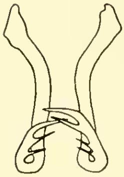
*Thorax:* Legs dark brown; fore and middle femora with pre-apical pale rings, all tibiae with subbasal pale rings. Hind tibial comb with 4 spines.

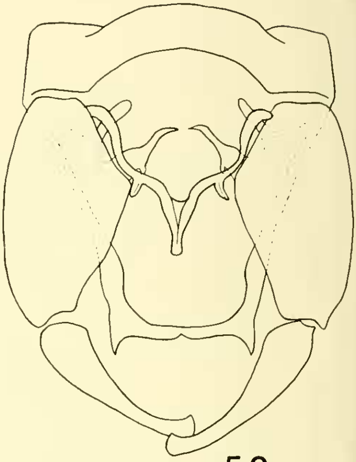
*Wing:* (Fig. 55). Second radial cell in a dark area; poststigmatic spot usually small, sometimes divided into 2 spots; pale spot in cell $R_5$ with mesal constriction, rarely divided into 2 spots; pale spots in cells $M_1$, $M_2$, $M_4$ and











Figs. 55-59. *Culicoides baueri* Hoffman. Female: 55, wing; 56, palpus; 57, spermathecae. Male: 58, claspettes; 59, genitalia, claspettes removed.

vannal cell, all well removed from wing margin; pale spot present over vein $M_2$; medio-cubital fork bordered posteriorly by a rather long pale spot; a small spot just posterior to r-m crossvein, separated from spot on r-m and spot forming posterior border of medio-cubital fork. Macrotrichia abundant. Costa extending 0.52 (0.48-0.55; n=10) of distance to wing apex.

*Abdomen:* Two subequal spermathecae (Fig. 57) 49 x 66 and 42 x 66 $\mu$, necks well developed; rudimentary spermatheca and ring present.

MALE—Genitalia (Figs. 58, 59) with ninth sternum broad, caudomedian excavation deep; membrane spiculate. Ninth tergum tapering posteriorly, with 2 pointed apicolateral processes and slight mesal notch. Basimere with long prominent roots; ventral root slender, tapering, almost touching opposite root mesally, with boat-shaped hook; dorsal root elongate but stouter.

Telomere tapering distally, with knobbed apex. Aedeagus with median posterior process sub-truncate; aedeagal arms widely separated anteriorly, bases sharply curved laterad, converging posteriorly to form median process; arms more or less sinuate with blade-like processes on posterior margin of shoulders. Claspette stout; broad basally, distal one-third strongly recurved, apex with a fringe of long slender spines.

*DISTRIBUTION:* *Culicoides baueri* is a widespread species that has been reported from Calif., Colo., Fla., Ga., Md., N.Y., Okla., Tenn., Texas, and Wis. New Mexico County Records: DeBaca, Catron, Lincoln, Otero, Quay and Sandoval.

*VARIATION:* There exists some variation in the pattern of pale wing spots in New Mexico specimens. When compared with the well defined patterns of the low-land specimens, representatives from some of the mountainous areas, such as at Alto (Lincoln County) exhibit some reduction in spot definition.

The distal pale spot in cell $R_5$ may vary from large and mesally constricted to two small spots.

### 11. **Culicoides haematopotus** Malloch

(Figs. 60-65)

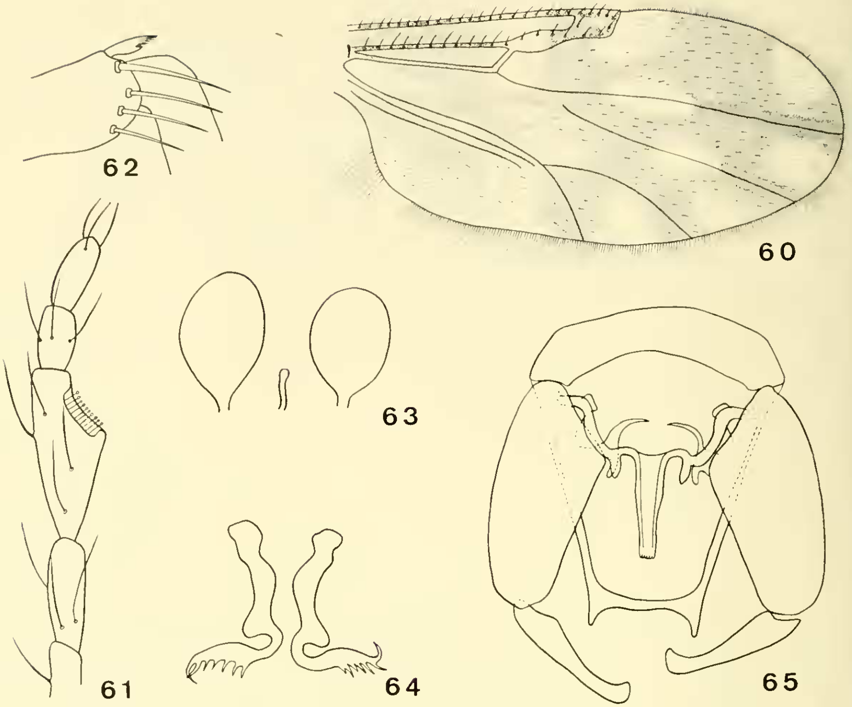
*Culicoides haematopotus* Malloch, 1915, Ill. State Lab. Nat. Hist. Bull. 10:302 (male, female; Illinois; fig. wing, male antenna, male genitalia).

FEMALE—Length of wing 1.17 (1.0-1.3; n=15) mm.

*Head:* Eyes separated less than diameter of a facet. Antenna with flagellomeres in proportion of 12:8:8:8:8:8:8:9:19:19:21:22:30; antennal ratio 1.43 (1.25-1.57; n=13); distal sensory tufts on segments 3, 5, 7, 9-15, occasionally present on segment 8 and rarely on 6 and 8 together (see discussion on variation for second form of *haematopotus*); segments 9+10 to 11 in ratio of 0.91 (0.83-1.0; n=12). Distal 4 palpal segments in proportion of 15:25:8:11; third segment moderately swollen, 2.5 (2.3-2.7; n=14) times as long as greatest breadth, with a broad but moderately shallow sensory organ (Fig. 61). Ratio of head length to proboscis 1.11 (0.97-1.25; n=11). Mandible with 12-15 (n=16) teeth.

*Thorax:* Legs brown; fore and middle femora with pre-apical pale rings, all tibiae with sub-basal pale rings; knees dark. Hind tibial comb with 4 spines, the spine nearest the spur usually longest (Fig. 62).

*Wing:* (Fig. 60). Second radial cell in a dark area; spot over r-m crossvein extending from anterior wing margin to just beyond vein $M_{1+2}$, may be connected to a second small pale spot and apparently extending to immediately anterior of medio-cubital fork; poststigmatic spot present, usually connected to spot over vein $M_1$; distal spots in cells $R_5$, $M_1$, $M_2$, $M_4$ and vannal cell, all attaining wing margin; 2 spots in vannal cell sometimes con-



FIGS. 60-65. *Culicoides haematopotus* Malloch. Female: 60, wing; 61, palpus; 62, tibial comb; 63, spermathecae. Male: 64, claspettes; 65, genitalia, claspettes removed.

nected along posterior margin of wing to form a "C"; spots present over mesal portions of vein $M_1$ and $M_2$; a small spot at base of medio-cubital fork. Macrotrichia present in distal and posterior portions of the wing. Costa extending to 0.55 (0.52-0.56; n=15) of distance to wing apex.

*Abdomen:* Two unequal, oval spermathecae (Fig. 62) 82 x 43 and 66 x 36 $\mu$, with ducts sclerotized for a long distance; rudimentary spermatheca and heavily sclerotized ring present.

MALE—Genitalia (Figs. 64, 65) with ninth sternum broadly, shallowly emarginate. Ninth tergum tapering posteriorly, with short, triangular apicolateral processes. Basimere tapering posteriorly; ventral root long, curved, with pointed apex, a large boot-shaped hook on posterior margin; dosal root broad, truncate. Telomere slender with slightly swollen apex. Aedeagus with very long, straight-sided median posterior process, with serrate, truncate apex; aedeagal arms turned laterad basally, curved postero-medially to form median posterior process; prominent triangular process on apical portion of aedeagal arms. Claspette with stout base; stem sinuate, with large, laterally directed thumblike lobe approximately at mid-length; stem narrowed immediately above lobe, turned laterad to form greatly swollen apex bearing numerous spines, outermost spine largest.

*DISTRIBUTION:* *Culicoides haematopotus* is a common species occurring over most of the United States. New Mexico County Records: Catron, DeBaca, Dona Ana, Eddy, Lincoln, Quay and Socorro.

*VARIATION:* Two forms of this species exist in New Mexico. One has a relatively small wing and an antennal sensorial pattern of 3, 5, 7, 9-15, and is here considered typical *haematopotus*; a second form possesses a large wing and a sensorial pattern of 3, 10-15. This second form can be characterized as having a larger wing (WL=1.38 mm.), a slightly smaller antennal ratio (AR=1.37), a slightly more swollen third palpal segment (PR=2.3) and a slightly longer 11th antennal segment (9+10 to 11=0.86). In this form some of the distal wing spots are reduced in size and intensity. No perceptible difference has been found in the male genitalia of the two forms. Intermediates between these two forms exist at Glenwood, Catron County, New Mexico.

The description by Jamnback (1965) of *haematopotus* as it occurs in New York differs markedly from that of specimens identified as this species in the southwestern United States. The differences between the eastern and western forms of this species and the presence of two forms or phases mentioned above would suggest that *haematopotus* as we now understand it is a complex of very similar species. A critical study is needed of what is now understood to be *haematopotus* to determine the extent of morphological and biological variation and to determine if this variation is specific, sub-specific or infrasubspecific.

An intersex of this species was collected at Glenwood, Catron Co., New Mexico.

*FEEDING HABITS:* Several authors have reported this species as biting man, but only in small numbers. Others, such as Fallis and Bennett (1960, 1961) and Messersmith (1965), have presented evidence that *haematopotus* may be ornithophilic. The studies by Snow (1955) on vertical distribution of biting flies would seem to support this latter premise, since he found this species to be more common in the forest canopy than at ground level.

### Subgenus *OECACTA* Poey, 1851:238 (as genus)

Type species *furens* Poey (monotype).

A rather diverse assemblage of species including those forms with the second radial cell usually in a dark area and commonly with a distinct wing pattern of pale and dark spots. Occasionally, however, the wings are more or less unicolorous and lack a pattern of spots. The females have two spermathecae, rarely one. The claspettes are separate and may or may not be modified apically. The basimere has well developed ventral roots, a boat-shaped hook may be present on the posterior margin and the dorsal root is usually long and simple. The apicolateral processes of the ninth tergum are usually prominent.

This subgenus, as currently defined, contains a heterogeneous accumulation of species groups. There exists considerable disagreement among various workers as to the contents of *Oecacta*. Many of the species groups now "lumped" into *Oecacta* will no doubt later be elevated to subgeneric status when their natural affinities become better understood.

### *Culicoides limai* Group

This group consists of species with large pale spots more or less filling the wing cells. A pale spot is found straddling vein $M_2$ and occasionally a second spot over $M_1$. The sensorial pattern is 3, 7-10 or 3-10 and there are four tibial spines. The male genitalia may or may not possess a foot-shaped ventral root. The apex of the claspette is fringed and a lobe or blade-like process may be present.

*Culicoides luglani* is provisionally referred to this group, but its affinities are still not clear. The *limai* group, as outlined by Wirth and Blanton (1958) for four Panama species, possess foot-shaped ventral roots and the median posterior process lacks lateral projections. Both *luglani* and *tenuilobus,* which it closely resembles, have simple ventral roots and the median process has prominent lateral projections. In addition, all the Panama representatives have a sensorial pattern of 3, 7-10 while *luglani* has 3-10.

### 12. **Culicoides luglani** Jones and Wirth

(Figs. 66-70)

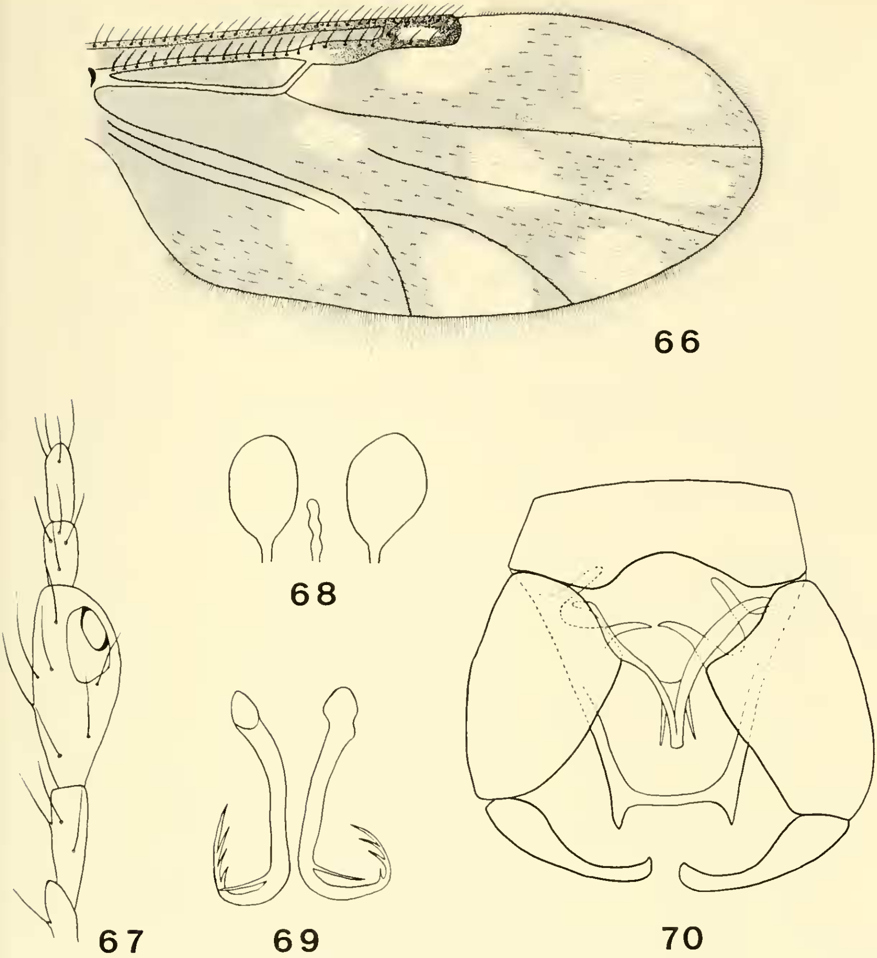
*Culicoides luglani* Jones and Wirth, 1958, J. Kansas Ent. Soc. 31:89-91 (male, female; Texas; fig. wing, mesonotal disc, spermathecae, palpus, male genitalia).

FEMALE—Length of wing 1.22 (1.17-1.26; n=3) mm.

*Head:* Eyes very narrowly separated. Antenna with flagellomeres in proportion of 10:10:10:11:11:11:12:12:15:15:18:18:21; antennal ratio 0.95 0.89-0.99; n=3); distal sensory tufts present on segments 3-10, rarely absent from 5; antennal segments 9+10 to 11 in ratio of 0.59 (0.58-0.60; n=3). Distal 4 palpal segments in proportion of 15:28:8:10; third palpal segment greatly swollen, 2.12 (2.0-2.2; n=3) times as long as greatest breadth, with a deep sense organ with a rounded opening (Fig. 67). Ratio of length of head to proboscis 1.05 (1.01-1.09; n=3). Mandible with 13-16 (n=3) teeth.

*Thorax:* Femora with pre-apical pale rings, tibiae with subbasal pale rings. Hind tibial comb with 4 spines.

*Wing:* (Fig. 66). Second radial cell in a dark area; small round pale spot over r-m crossvein, extending from anterior margin of wing to barely be-



FIGS. 66-70. *Culicoides luglani* Jones and Wirth. Female: 66, wing; 67, palpus; 68, spermathecae. Male: 69, claspettes; 70, genitalia, claspettes removed.

yond vein $M_{1+2}$; poststigmatic spot narrow; a large pale spot in distal portion of cell $R_5$; spot in distal portion of cell $M_1$ not attaining wing margin; pale spots in cells $M_2$ and $M_4$ both attaining wing margin; 2 small pale spots in vannal cell, neither reaching posterior edge of wing; a pale spot circumscribing vein $M_2$ extending anteriorly to posterior edge of vein $M_1$; a small spot in extreme proximal portion of cell $M_2$ lying just below r-m crossvein; medio-cubital fork in a dark area. Macrotrichia confined to distal and posterior portions of wing. Costa extending to 0.53 (0.52-0.56; $n=3$) of distance to wing apex.

*Abdomen:* Two slightly unequal spermathecae (Fig. 68) with long sclerotized necks, 73 x 50 and 66 x 46 μ. Rudimentary spermatheca and ring present.

MALE—(Figs. 69, 70). Ninth sternum with narrow, rather shallow emargination. Ninth tergum strongly tapering, with small triangular apicolateral processes. Basimere tapering distally; roots prominent, ventral root with simple, expanded base, not tapering to point, almost touching mesally. Telomere swollen basally, then narrowing to slightly swollen tip. Median posterior process of aedeagus elongate with two rather obscure lateral lobes at apex; aedeagal arms long, slender and slightly bowed mesally, bases turned laterad. Lateral lobes of median process much stouter in New Mexico specimens than pictured by Wirth and Jones. Claspette with knobbed base; stem stout basally, tapering posteriorly; mesal margin of stem relatively straight, lateral margin with slight median swelling; distal portion of stem gently recurved, bearing several small, slender spines; a large, strong, laterally directed spine arising just before lateral curve of stem.

*DISTRIBUTION:* Texas, Arizona, Mexico. New Mexico County Records: Catron, DeBaca, Grants and Lincoln.

*VARIATION:* The New Mexico material of this species differs somewhat from the original description. The proboscis of the New Mexico specimens is considerably shorter than that of Texas individuals.

*DISCUSSION:* Females of this species superficially resemble members of the *palmerae* group, particularly with regard to the wing pattern. The sensorial pattern will readily separate *luglani* from *novamexicanus* n. sp. With regard to *palmerae* and *utahensis*, separation can be made by the shape of the third palpal segment, the antennal ratio and eye separation. The genitalia of the males are quite distinct.

Close examination of material identified as *tenuilobus* Wirth and Blanton from Panama in the USNM shows *luglani* and *tenuilobus* not to be synonomous as previously thought (Wirth 1963).

## *Culicoides furens* Group

The *furens* group is composed of an assemblage of species which often possess pale spots in the extreme distal portions of cells $R_5$ and $M_1$. The sensorial pattern is 3, 8-10 and there are four or five tibial spines. The spermathecae have distinct selerotized necks. The ventral root of the male genitalia is foot-shaped and the claspettes have simple bases, a ventral lobe on the stem and an apical fringe of spines.

### 13. **Culicoides stellifer** (Coquillett)

(Figs. 71-76)

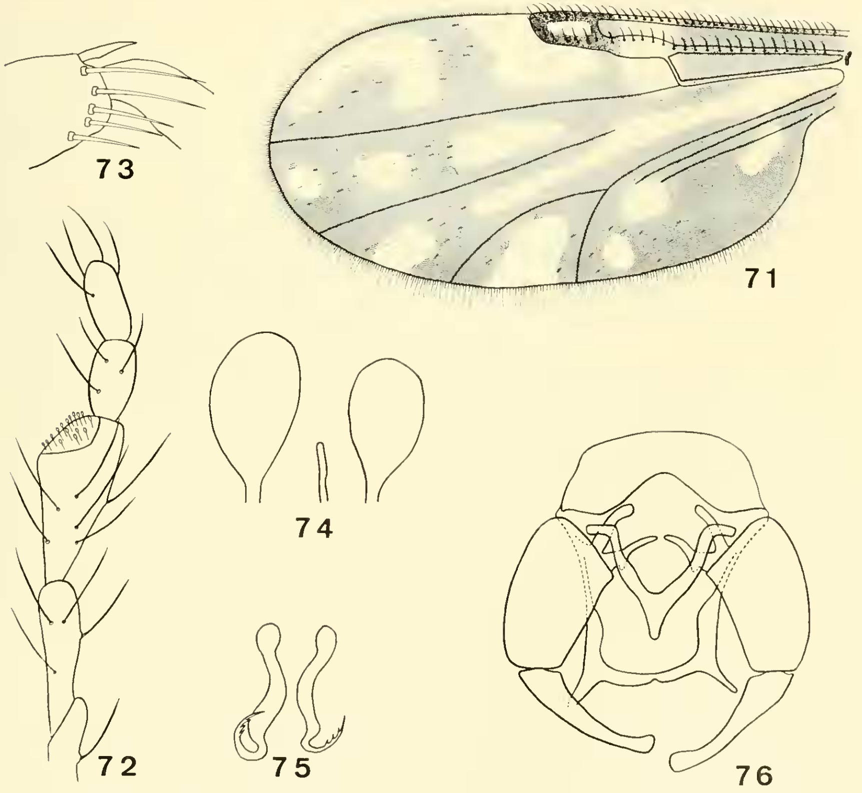
*Ceratopogon stellifer* Coquillett, 1901, U.S. Nat. Mus. Proc. 23:604.
*Culicoides stellifer* (Coquillett); Kieffer, 1906, Gen. Insectorum, fasc. 42:55.

FEMALE—Length of wing 1.24 (1.18-1.32; n=12) mm.

*Head:* Eyes separated less than diameter of a facet; inferior transocular suture always present. Antenna with flagellomeres in proportion of 10:10:10: 10:11:11:11:11:13:16:17:17:30; antennal ratio 0.96 (0.90-1.07; n=10); distal sensory tufts on segments 3, 7-10, occasionally absent from 7, rarely present on 5 and 6; segments 9+10 to 11 in ratio of 0.62 (0.54-0.78; n=11). Distal 4 palpal segments in proportion of 17:22:8:10; third palpal segment moderately swollen, 2.47 (2.25-2.87; n=11) times as long as greatest breadth (Fig. 72). Ratio of head length to proboscis 1.22 (1.11-1.28; n=8). Mandible with 12-14 (n=10) teeth.

*Thorax:* Legs dark brown; fore and middle femora with pre-apical pale ring; all tibiae with subbasal pale rings; hind tibiae with long, apical pale area indistinct on fore and middle tibiae. Hind tibial comb with 5 spines (Fig. 73).

*Wing:* (Fig. 71). Second radial cell in a dark area; spot over r-m crossvein extending from costa to vein $M_{1+2}$; poststigmatic spot mesally con-



Figs. 71-76. *Culicoides stellifer* (Coquillett). Female: 71, wing; 72, palpus; 73, tibial comb; 74, spermathecae. Male: 75, claspettes; 76, genitalia, claspettes removed.

stricted, basal portion of spot larger and extending proximally behind second radial cell; spot in cell $R_5$ "C" shaped, following anterior and distal margins of the wing; 2 spots in distal portion of cell $M_1$, apical spot and spots in cells $M_2$ and $M_4$ attaining wing margin; 2 round spots in distal part of vannal cell; an elongate triangular-shaped pale area lying at basal end of cell $M_1$; a long pale area in basal portion of cell $M_2$ beginning at arculus and extending well beyond medio-cubital fork. Macrotrichia rather sparse, occurring primarily on marginal part of wing. Costa extending 0.54 (0.50-0.58; n=12) of distance to wing apex.

*Abdomen:* Two unequal spermathecae (Fig. 74) 69 x 40 and 60 x 34 $\mu$, (n=5); ducts well developed.

MALE—(Figs. 75, 76). Ninth sternum broad, with a narrow, deep caudomedial excavation. Ninth tergum tapering, with long, slender, finger-like apicolateral processes. Basimere with prominent roots; ventral roots elongate, almost touching mesally, each with a distinct hook on posterior margin; dorsal root long and slender. Telomere tapering, with slightly swollen apex. Aedeagus in shape of V; median posterior process short, posteriorly rounded; aedeagal arms widely separated anteriorly, basal ends sharply curved laterad, converging posteriorly to form median process; basal arch rounded. Claspette with knobbed base; stems stout, sinuate; apical third strongly recurved and bearing spines; stem with slightly swollen lobe located immediately anterior to narrowed recurved apex.

*DISTRIBUTION:* This is a common and very widespread species, having been recorded from the majority of states in the U.S. from Canada to Mexico, in addition to Trinidad and Venezuela. New Mexico County Records: DeBaca, Lincoln, Otero, San Miguel and Taos.

*VARIATION:* A female specimen from Taos County exhibits an atypical wing pattern in that the "C" shaped spot in cell $R_5$ lacks the heavier basal area and is, therefore, reduced to a curved line along the wing margin. Other specimens from Lincoln Co. have this spot divided into a mesally constricted proximal portion with its prolongation reduced to a small spot in the very distal part of the cell, reminiscent of the pattern in *C. paraensis* (Goeldi). Many specimens exhibit considerable variation in the number and position of the pale spots in cell $M_1$. The two distal pale spots in this cell may be separate, narrowly joined or completely fused. A female from Bonita Lake, Lincoln Co. has in cell $M_1$ a triangular spot in the proximal portion of the cell narrowly joined to the two completely fused distal spots.

*FEEDING HABITS:* This species has been reported as biting man in Utah by Rees and Bullock (1954), while Malloch (1915), Hoffman (1925), Root and Hoffman (1937) and Murray (1957) have cited man-biting records in the eastern states. Snow *et al.* (1957) found that man-biting records believed to pertain to *stellifer* in the Tennessee Valley were *paraensis* (Goeldi).

Therefore, many eastern biting records for *stellifer* may be in error. Khalaf (1966) has given characters sufficient to distinguish these two species.

### *Culicoides stonei* Group

The *stonei* group includes species with unmarked wings, a sensorial pattern of 3-14, 3, 7-14 or 3, 9-14, pale legs without a distinct banding pattern and the spermathecal system lacks a sclerotized ring. The male genitalia possesses very long, stout, diverging apicolateral processes and the mesal margin of the ninth tergum has a row of stout spines. The aedeagus has slender basal arms and the median posterior process is broadly rounded apically . The claspettes possess slender anterior processes on the basal knob.

This group, as outlined above, includes *C. stonei* James and two apparently undescribed species in the USNM collections. The shape of the anterior process on the basal knob of the claspettes, the very prominent apicolateral processes and the absence of a sclerotized ring closely ally the *stonei* group with the *biguttatus* and *spinosus* groups.

### 14. Culicoides stonei James

(Figs. 77-81)

*Culicoides stonei* James, 1943, Pan-Pacific Ent. 19:149 (male, female; Colorado; fig. male genitalia).
*Culicoides weesei* Khalaf, 1952, Jour. Kansas Ent. Soc. 25:65.

FEMALE—Length of wing 1.17 (1.06-1.22; n=6) mm.

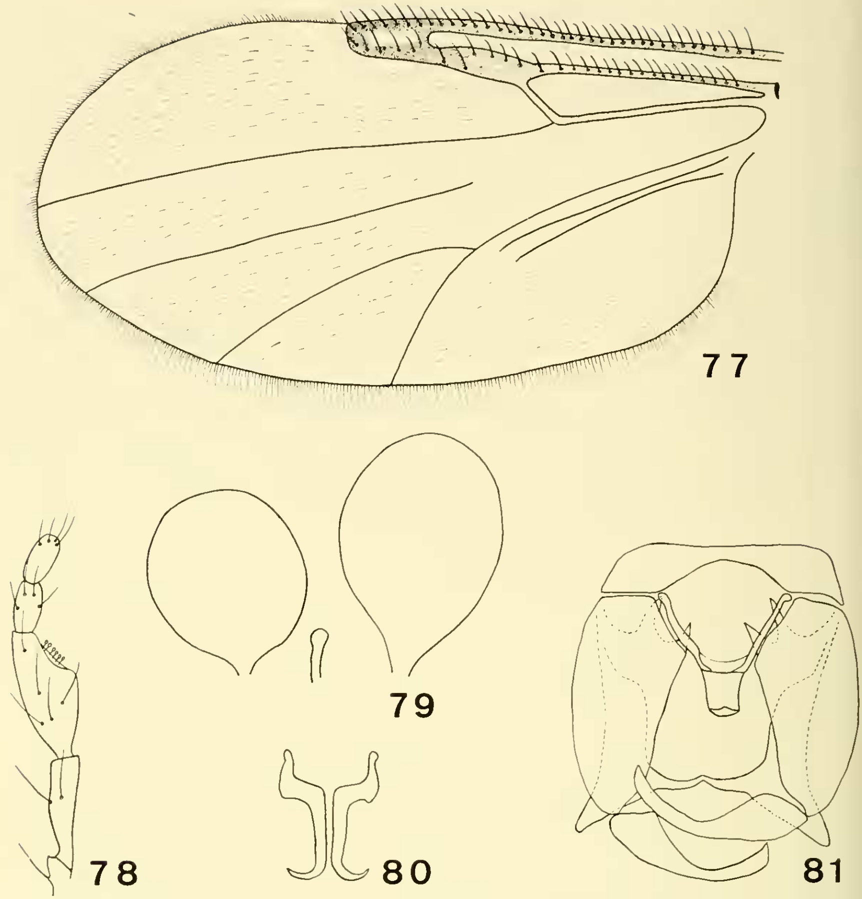
*Head:* Eye separation approximately half the diameter of a facet. Antenna with flagellomeres in proportion of 11:8:9:10:10:9:10:10:14:13:16:18:21; antennal ratio 1.10 (1.05-1.15; n=6); segments 9+10 to 11 in ratio 0.69 (0.65-0.72; n=5). Distal sensory tufts on segments 3-14 (15), occasionally absent from segment 4. Distal 4 palpal segments in proportion of 20:24:10:8; third palpal segment swollen, 2.3 (2.1-2.4; n=6) times as long as greatest breadth, with shallow sensory pore, from which arise numerous stalked sensillae (Fig. 78). Ratio of head length to proboscis 1.04 (1.01-1.09; n=5). Mandible with 12-13 teeth (n=7).

*Thorax:* Legs pale, without apparent banding pattern. Hind tibial comb with 4 spines.

*Wing:* (Fig. 77). Wings with no pattern of light or dark spots. Costa extending 0.56 (0.55-0.58; n=6) of entire length of wing. Macrotrichia relatively abundant.

*Abdomen*: Two large, heavily sclerotized, unequal spermathecae (Fig. 79); ducts well developed; rudimentary spermatheca present, ring absent.

MALE—Genitalia (Figs. 80, 81) with ninth sternum possessing narrow deep caudomedial excavation; membrane spiculate. Ninth tergum with very prominent, broad, divergent apicolateral processes; posterior portion of ninth



Figs. 77-81. *Culicoides stonei* James. Female: 77, wing; 78, palpus; 79, spermathecae. Male: 80, claspettes; 81, genitalia, claspettes removed.

tergum distinctly notched. Basimere with long, simple roots, dorsal root longer than ventral root. Aedeagus with very broad, sub-truncate median posterior process; aedeagal arms slender, straight, divergent, with slight postero-laterally directed bases. Claspette stout basally; basolateral process with tapering anterior extension; stems narrowing slightly to sickle-like apex.

*DISTRIBUTION: Culicoides stonei* has been previously reported from the western half of the United States, Texas to South Dakota, westward to California. New Mexico County Records: Chaves, DeBaca, Eddy, Quay and Roosevelt.

*DISCUSSION:* The unmarked wings of this species resemble those of *bottimeri* Wirth, but these two species can be separated by sensorial pattern of the females and very distinctive male genitalia. In addition, the unmarked wings of *stonei* superficially resemble various species of the subgenus *Selfia;* however, the presence of well sclerotized spermathecae in *stonei* will easily differentiate females of these species.

### *Culicoides spinosus* Group

The females of this group have poorly marked wings lacking distal pale spots, sensoria on segments 3, 11-15 (except *usingeri*), eyes narrowly separated to contiguous, and the ring is absent. (Examination of type material of *usingeri* Wirth showed the ring not present as previously thought.) The male genitalia have prominent apicolateral processes and the claspettes, which bear marginal spines, have stems bent at almost right angles with the bases.

The *spinosus* group, as outlined above, includes *spinosus* Root and Hoffman, *loisae* Jamnback, *usingeri* Wirth and *sublettei* n. sp. These species, included in the *biguttatus* group by many authors, appear to form a closely related group because of the great similarity of the male genitalia as well as the wing pattern, sensorial pattern, etc.

### 15. **Culicoides sublettei** new species

(Figs. 2, 82-87)

FEMALE—Length of wing 1.19 (1.08-1.27; n=12) mm.

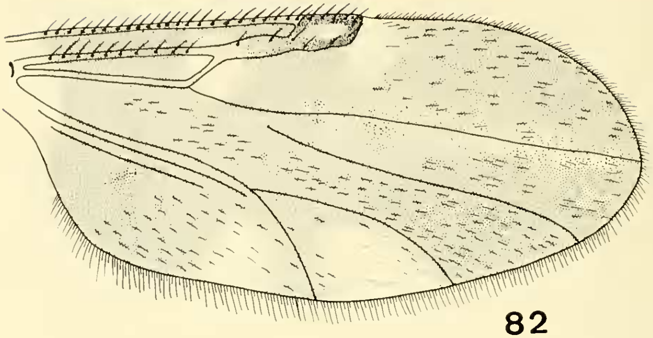
*Head:* Eyes separated less than diameter of a facet; inferior interocular suture present (very faint in allotype female). Antnna with flagellomeres in proportion of 10:8:8:8:10:10:11:11:15:17:18:18:25; antennal ratio 1.07 (1.03-1.13; n=3); segments 9+10 to 11 in ratio of 0.67 (0.65-0.72; n=4); distal sensory tufts on segments 3, 11-15, rarely absent from 11. Distal 4 palpal segments in proportion of 17:23:12:8; third palpal segment swollen (Fig. 83), 2.37 (2.08-2.60; n=10) times as long as greatest breadth, with moderately shallow, round sensory pore. Ratio of head length to proboscis 1.05 (0.90-1.12; n=9). Mandible with 14-16 (n=11) teeth.

*Thorax:* Legs brown, without distinct banding on femora or tibiae. Hind tibial comb with 4 spines (Fig. 84).

*Wing:* (Fig. 82). Wing with faint pattern; second radial cell in a dark area; small, round spot over r-m crossvein, extending barely beyond vein $M_{1+2}$; poststigmatic spot very small; pale spots in cell $M_4$ and distal portion of vannal cell, both attaining wing margin; a very indistinct pale spot in distal portion of cell $M_2$. Costa extending 0.55 (0.53-0.59; n=12) of length of wing. Macrotrichia abundant over entire wing surface.

*Abdomen:* Two dark equal spermathecae (Fig. 85) 66 x 43 $\mu$ (slightly unequal in one paratype), ducts sclerotized for a short distance; rudimentary spermatheca present, ring absent.

MALE—(Figs. 86, 87). Genitalia with ninth sternum having narrow, shallow posterior emargination. Ninth tergum with broad, pointed apicolateral processes. Basimere with slender, simple roots. Telomere arcuate, stout



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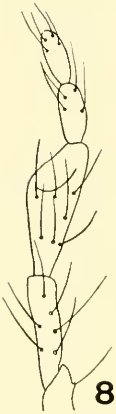

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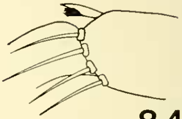

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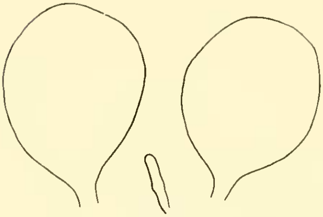

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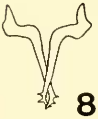

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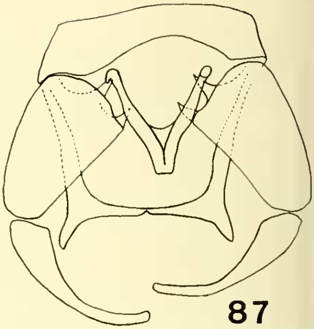

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FIGS. 82-87. *Culicoides sublettei,* new species. Female: 82, wing; 83, palpus; 84, tibial comb; 85, spermathecae. Male: 86, claspettes; 87, genitalia, claspettes removed.

basally, tapering distally, with simple apex. Aedeagus with short, broad, truncate median posterior process; aedeagal arms widely separated anteriorly, with small, postero-laterally directed bases, arms converging posteriorly to form median process; basal arch gently rounded, extending approximately half length of entire aedeagus. Claspette with basal end L-shaped, anterior process pointed; stem slender, diminishing posteriorly to slightly curved, pointed apex, bearing two small but distinct sub-apical spines.

*DISTRIBUTION:* New Mexico (DeBaca and Quay Counties) and Texas.

*Specimens examined:* Holotype male, Ft. Sumner, DeBaca County, New Mexico, 8 June 1964, at light, NMDPH. Allotype female, same data. Paratypes, 1 males, 12 females: 1 male, 7 females, Ft. Sumner, 8 June 1964; 5 females, Ft. Sumner, 15-18 June 1964. Additional specimens examined: 1 female, Balmorhea State Park, Reeves Co., Texas, 24 Aug. 1964, F. S. Blanton.

*DISCUSSION: Culicoides sublettei* n. sp. belongs to the *spinosus* group, being closest to *spinosus* Root and Hoffman and *loisae* Jamnback, both of which occur in the eastern United States. *C. sublettei* is very similar to the figures given by Jamnback for *loisae;* however, the females may be distinguished from this species by the presence of distinctly denticulate mandibles. The more swollen third palpal segment as well as the longer proboscis in relation to the head length will separate *sublettei* females from those of *spinosus.*

The male genitalia of *sublettei* have stouter and slightly bowed aedeagal arms with truncate tips, while in *loisae* the arms are straight. In both eastern species the apex of the aedeagus is rounded or sharply narrowed.

In the western states *sublettei* may be separated from *usingeri* Wirth by the sensorial pattern and the presence of five tibial spines in *usingeri.* Males of *usingeri* have a conical median posterior process of the adeagus and about five spines on the claspettes.

I am very happy to name this species for my good friend and former teacher, Dr. James E. Sublette, who first interested me in the study of Diptera.

### *Culicoides daedalus* Group

The *daedalus* group, as outlined by Wirth and Blanton (1959), has females with very hairy wings. A pale spot straddles vein $M_2$ and sensoria are found on segments 3, 11-15 or 3, 5, 7, 9, 11-15. The pit of the third palpal segment is broad and shallow or deep and opening by a small pore. The male genitalia possess slender, unmodified ventral roots, the claspettes are pointed apically with distinct anterior processes on the basal knobs, and the aedeagus is simple.

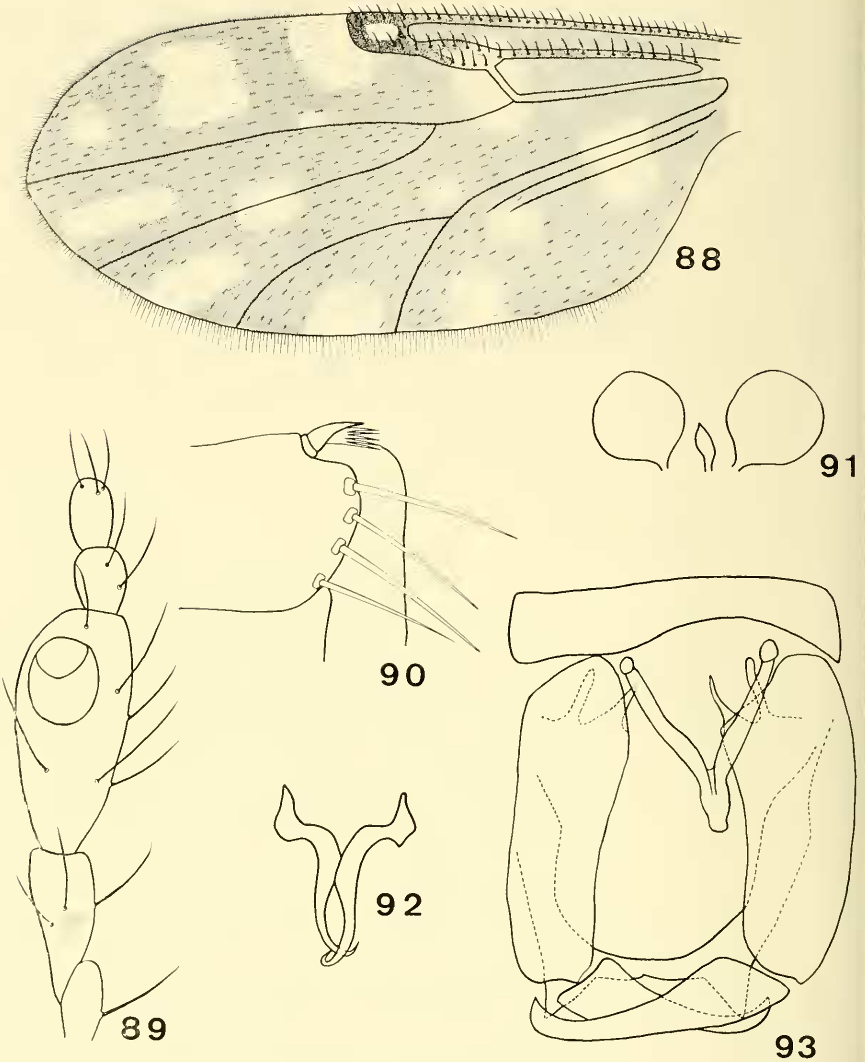
### 16. **Culicoides pampoikilus** Macfie

(Figs. 88-93)

*Culicoides pampoikilus* Macfie, 1948, Ann. Trop. Med. Parasit., 42:79 (female; Chiapas, Mexico; fig. wing).
*Culicoides dominicii* Ortiz, 1951, Nov. Cient. Mus. Hist. Nat. LaSalle, zool. ser., no. 5:7.

FEMALE—Length of wing 1.52 mm.

*Head:* Eyes contiguous. Antenna with flagellomeres in proportion of 14:12:13:12:12:12:13:14:23:24:26:27:36; antennal ratio 1.55; segments 9+10 to 11 in ratio of 0.89; distal sensory tufts present on segments 3, 5, 7, 9, 11-15, occasionally present on segments 4 and 8 (only specimen from New Mexico has sensoria on segment 4 on 1 antenna and 8 on other). Distal 4 palpal segments in proportion of 15:30:8:8; third palpal segment very swollen, 2.0 times as long as greatest breadth, with large, deep sensory pore (Fig. 89). Ratio of head length to proboscis 1.32. Mandible with 15 very small teeth.



Figs. 88-93. *Culicoides pampoikilus* Macfie. Female: 88, wing; 89, palpus; 90, tibial comb; 91, spermathecae. Male: 92, claspettes; 93, genitalia, claspettes removed.

*Thorax:* Hind femora darker than middle and fore pair. Banding pattern not evident on available female specimen, described by Wirth and Blanton (1959) as follows: "fore and mid femora with subapical and all tibiae with subbasal narrow pale rings." Hind tibial comb with 4 spines (Fig. 90).

*Wing:* (Fig. 88). Second radial cell in a dark area; pale spot on r-m crossvein, extending posteriorly beyond vein $M_{1+2}$; small, narrow, poststigmatic spot; 2 pale spots in cell $R_5$ in addition to poststigmatic spot, a large spot located more or less in middle of cell $R_5$ and a small, faint spot at distal margin; pale spots in cells $M_1$, $M_2$ and $M_4$ all reaching wing margin; two pale spots in distal portion of vannal cell, distalmost attaining wing margin; pale spot on vein $M_2$; small pale spot over medio-cubital fork; large pale spot in proximal portion of wing broadly overlapping veins $Cu_1$, $Cu_2$ and 1V. Costa extending 0.54 of wing length. Macrotrichia abundant on entire surface.

*Abdomen:* Two small spermathecae (Fig. 91) with ducts sclerotized for a short distance (spermathecae crumpled in New Mexico specimen); rudimentary spermatheca slightly expanded.

MALE—Male genitalia described from specimen from Cartago, Navarro, Costa Rica (Figs. 92, 93). Ninth sternum with slight caudomedian excavation. Ninth tergum with prominent triangular apicolateral processes. Basimere long, slender; dorsal and ventral roots elongate, slender, subequal. Telomere tapering, with distinctly hooked apex. Aedeagus with median posterior process slightly expanded mesally, truncate; aedeagal arms long, slender, slightly sinuate, with postero-laterally directed bases; basal arch pointed, extending approximately 0.35 of entire length of aedeagus. Basal end of claspette with slender, pointed process; stem rather stout basally, tapering distally, with simple, strongly sinuate apex.

*DISTRIBUTION:* *Culicoides pampoikilus* is a tropical species, having previously been reported from Costa Rica, Mexico, Panama and Venezuela. Wirth and Blanton (1959) list *pampoikilus* as a rare species in the humid tropics of Panama. The following record of this species from the mountainous region of southern New Mexico constitutes a new United States record: Lincoln Co., Rudioso, Cedar Creek Canyon, elev. 7100 ft., 16 July 1965, at light, W. R. Atchley.

*DISCUSSION:* The single female specimen of this species was examined by Dr. Willis Wirth, who concluded that it was *pampoikilus*. The *daedalus* group, to which this species belongs, is most numerous in western Panama, according to Wirth and Blanton (1959). *Culicoides pampoikilus* is apparently not closely related to any other species in the New Mexico fauna.

## *Culicoides leoni* Group

Wirth and Blanton (1959) erected the *leoni* group for a small assemblage of species possessing almost bare wings. The distal portion of the wings is marked by two transverse rows of pale spots: one in line with the poststigmatic spot, the other with the distal pale spot in cell $R_5$. The antennal segments of the females are in 2 series: one from 3 to 10, the other from 11 to 15. Each series gradually increases in length from the proximal segment so that segment 11 is shorter than 10. Sensoria are located on segments 3, 7 or 8 to 10, there are 4 tibial spines and one spermatheca. The male genitalia have short claspette stems which may or may not possess mesal lobes.

### 17. Culicoides reevesi Wirth

(Figs. 94-98)

*Culicoides reevesi* Wirth, 1952, Univ. Calif. Pub. Ent. 9:193 (female; Calif.; fig. wing).

FEMALE—Length of wing 0.85 (0.82-0.88; n=2) mm.

*Head:* Eyes very narrowly separated, considerably less than diameter of a facet. Antenna with flagellomeres in proportion of 10:8:8:11:12:12:10:13:8:8:13:12:18; antennal ratio 0.65 (0.64-0.66; n=2); distal sensory tufts on segments 3, 8-10; segments 9+10 to 11 in ratio of 0.33 (0.31-0.34; n=2) (Fig. 98). Distal 4 palpal segments in proportion of 12:15:6:5; third segment only slightly swollen, 2.1 times as long as greatest breadth; sensory organ very deep (Fig. 95). Ratio of head length to proboscis 1.16. Mandible with 14-16 (n=3) teeth.

*Thorax:* Legs pale brown; fore and middle femora with subapical pale bands; all tibiae with subbasal pale bands, hind tibia with indistinct apical pale band. Hind tibial comb with 4 spines (Fig. 96).

*Wing:* (Fig. 94). Second radial cell in a dark area; spot on r-m crossvein extending from costa to vein $M_{1+2}$; poststigmatic spot large, extending almost to vein $M_1$; round spot in cell $R_5$ and spot in cell $M_1$ not attaining wing margin; pale spots in cells $M_2$ and $M_4$ attaining wing margin; spot in vannal cell extending along wing margin for almost entire length of cell; small spot in distal portion of cell $M_1$ on proximal portion of vein $M_2$; elongate pale area extending proximally from approximately fork of $M_{1+2}$ and medio-cubital fork to arculus. Macrotrichia sparse, occurring only in distalmost portions of cells $R_5$, $M_1$ and $M_2$. Costa extending 0.56 (0.54-0.56; n=3) of length of wing.

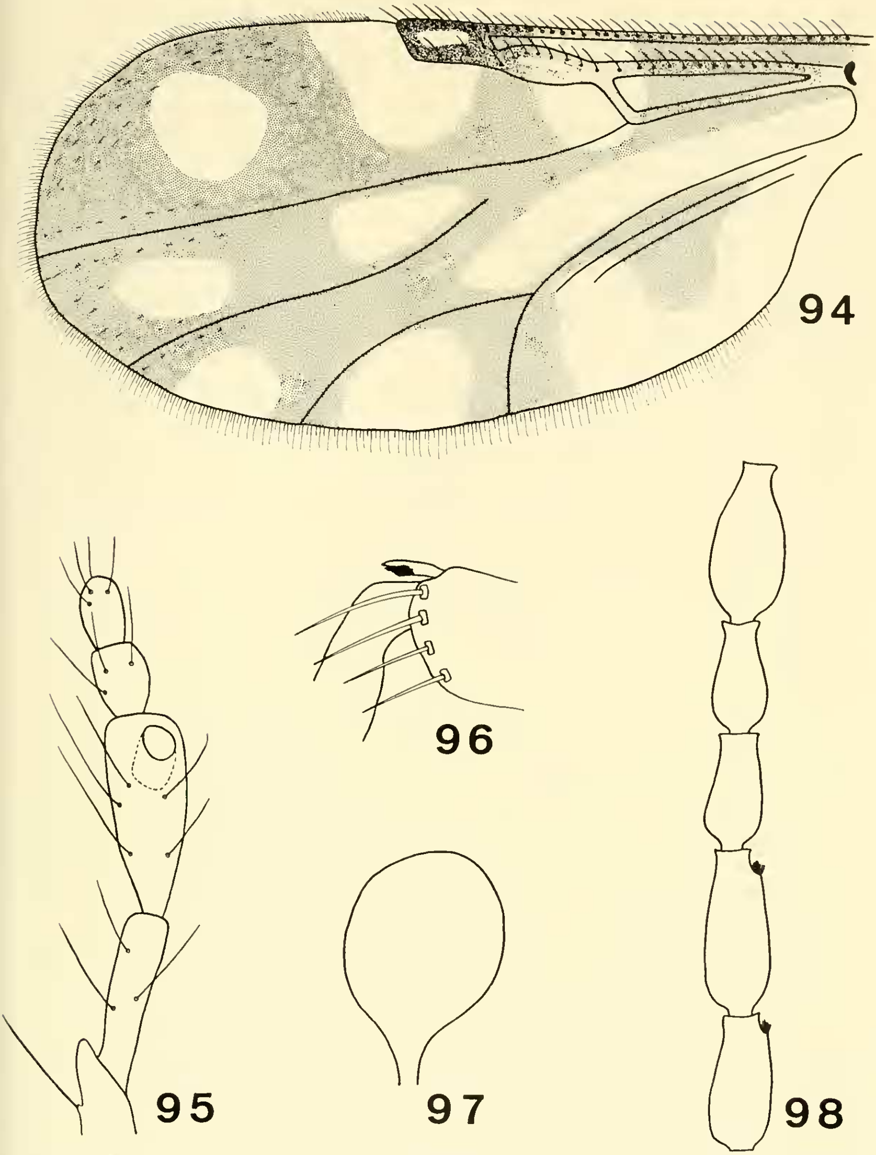
*Abdomen:* One subspherical spermatheca (Fig. 97) 56 x 36 $\mu$; duct sclerotized for some distance.

MALE—Unknown.

*DISTRIBUTION:* This species has been reported from California, Arizona, and New Mexico. During this investigation it was taken at the following localities: Catron (5 mi. e. of Glenwood, 24 June 1953, W. W. Wirth, biting man), Grant (Cherry Creek near Pinos Altos, 22 June 1953, W. W. Wirth, biting man; Roberts Lake north of Silver City, 31 July 1965, W. R. Atchley, biting man) and Rio Arriba counties.

*DISCUSSION:* *Culicoides reevesi* is not closely allied to any other New Mexico species, but it is nearest to a group of neotropical taxa centered around *leoni* Barbosa.

The presence of a single spermatheca and the unusual shape of antennal segments 11 and 12 will readily separate this species.



Figs. 94-98. *Culicoides reevesi* Wirth. Female: 94, wing; 95, palpus; 96, tibial comb; 97, spermatheca; 98, antennal segments 9-13.

*FEEDING HABITS:* This is a man-biting species previously reported as attacking man in California. In New Mexico it has been collected biting man at three localities in the western portion of he state. My own records indicate that this species is probably crepuscular, attacking at approximately sunset.

### *Culicoides guttipennis* Group

This group has females characterized by having the anterior half of the mesonotal disc with light markings on a dark background (except *ousairani,* which has the anterior half dull), well marked wings with macrotrichia abundant over most of the wing and 5 tibial spines. The male genitalia have basimeres with simple roots and the apicolateral processes of the ninth tergum are well developed. The claspettes are usually swollen mesally, tapering distally to more or less blunt points and lacking apical spines.

Vargas (1960) proposed the subgenus *Glaphiromyia* for this group of species.

### 18. **Culicoides pecosensis** Wirth

(Figs. 99-104)

*Culicoides pecosensis* Wirth, 1955, Wash. Acad. Sci. Jour. 45:358 (male, female; Texas; fig. wing, mesonotal disc, palp, male genitalia).

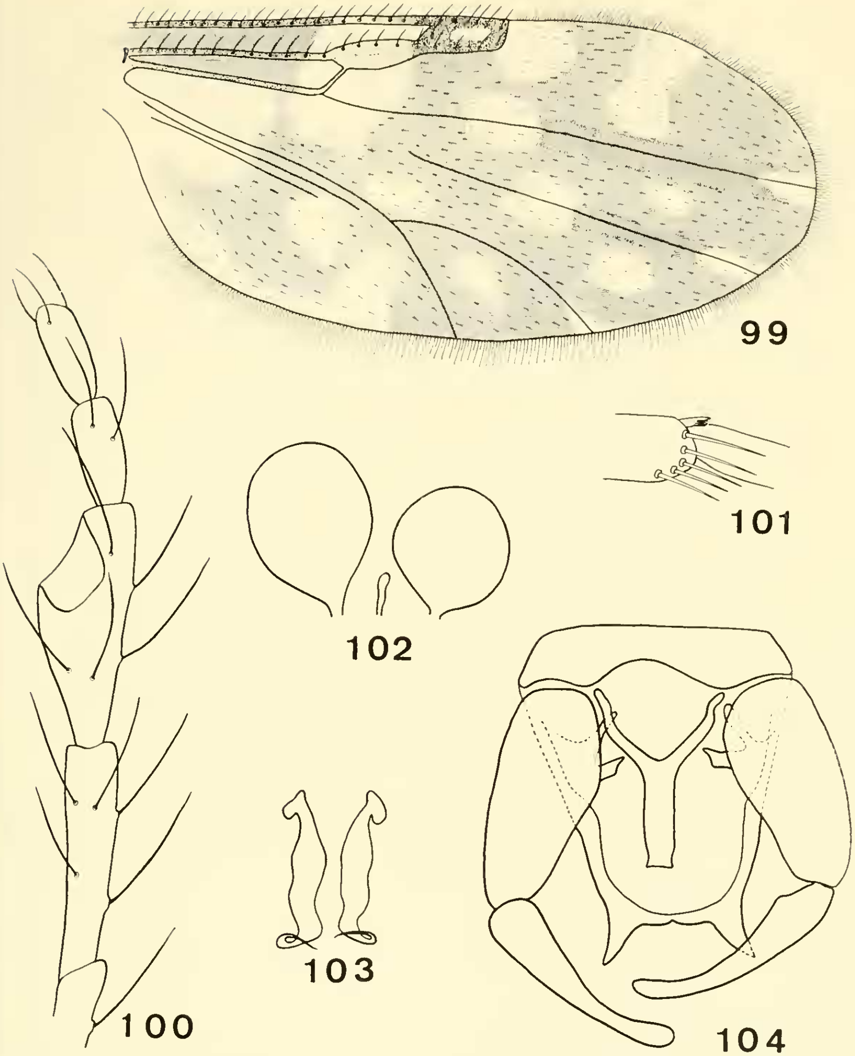
FEMALE—Length of wing 1.22 (1.17-1.34; n=6) mm.

*Head:* Eyes very narrowly separated to contiguous. Antenna with flagellomeres in proportion of 13:13:13:13:12:12:12:12:19:20:22:23:30; antennal ratio 1.25 (1.21-1.34; n=5); segments 9+10 to 11 in ratio of 0.81 (0.79-0.87; n=6); distal sensory tufts more or less irregular in occurrence, usually on segments 3-7, 9, 11-14. Distal 4 palpal segments in proportion of 23:26:11:10; third palpal segment moderately swollen, 2.48 (2.33-2.60; n=7) times as long as greatest breadth, with shallow sensory pore (Fig. 100). Ratio of head length to proboscis 0.93 (0.84-1.0; n=6). Mandible with 17-18 (n=6) teeth.

*Thorax:* Legs dark brown; femora with pre-apical pale bands; tibiae with subbasal pale bands, hind tibia with broad apical band. Hind tibial comb with 5 spines (Fig. 101).

*Wing:* (Fig. 99). Second radial cell in a dark area; spot over r-m crossvein large, extending from costa well beyond vein $M_{1+2}$ where it joins another rather indefinite pale area in proximal portion of wing; poststigmatic spot small; cell $R_5$ with an elongate, mesally constricted spot; small round spots in distal portions of cell $M_1$ and $M_2$; pale spot extending posteriorly in $M_4$ from vein $M_{3+4}$; none of preceding spots attaining wing margin; 2 spots in distal portions on vannal cell; pale spot over vein $M_1$ immediately posterior of poststigmatic spot; a double spot bordering each side of mesal portion of vein $M_2$; a small spot over medio-cubital fork; apices of veins $M_1$, $M_2$ and $M_{3+4}$ pale. Costa extending 0.54 (0.53-0.55; n=6) of entire wing length. Macrotrichia abundant over entire surface of wing.

*Abdomen:* Two slightly unequal spermathecae (Fig. 102) 57 x 42 and 47 x 35 $\mu$; ducts sclerotized for a very short distance. Rudimentary spermatheca and ring present.



Figs. 99-104. *Culicoides pecosensis* Wirth. Female: 99, wing; 100, palpus; 101, tibial comb; 102, spermathecae. Male: 103, claspettes; 104, genitalia, claspettes removed.

MALE—Description of genitalia based on male paratype (Figs. 103, 104). Ninth sternum with broad, shallow excavation. Ninth tergum narrowing posteriorly, with long prominent, triangular, apicolateral processes. Basimere with simple, prominent roots. Telomere slightly bowed, tapering apically. Aedeagus with extended, truncate median posterior process; aedeagal arms slender, straight but slightly sinuate basally; basal arch not markedly rounded, extending about 0.40 of entire length of aedeagus. Claspettes with strong postero-laterally directed bases; stems constricted immediately behind basal end, then greatly expanded, mesal portion of stem very stout, distal third of stem abruptly narrowed, apex contorted.

*DISTRIBUTION:* *Culicoides pecosensis* has been previously known only from Texas. This is the first recording of this species from New Mexico (Catron Co.).

*DISCUSSION:* Females of this species can be separated from the other members of the *guttipennis* group by the following characters: the anterior half of the mesonotum has a pattern of light and dark markings which are absent from *ousairani* Khalaf; a large spot on the r-m crossvein which in *pecosensis* extends well beyond vein $M_{1+2}$, barely extends beyond vein $M_{1+2}$ in *villosipennis* Root and Hoffman; the pale spot which extends along vein $Cu_1$ posteriorly to the wing margin will distinguish *pecosensis* from *guttipennis* (Coquillett), *arboricola* Root and Hoffman and *oklahomensis* Khalaf. The male genitalia of *pecosensis* lack the subapical aedeagal processes of *villosipennis* and *oklahomensis* and the truncate aedeagus of *pecosensis* and *ousairani*, and are distinctly different from those of *guttipennis*.

## 19. **Culicoides oklahomensis** Khalaf

(Figs. 105-108)

*Culicoides villosipennis oklahomensis* Khalaf, 1952, Ann. Ent. Soc. Amer. 45:355 (male; Oklahoma).

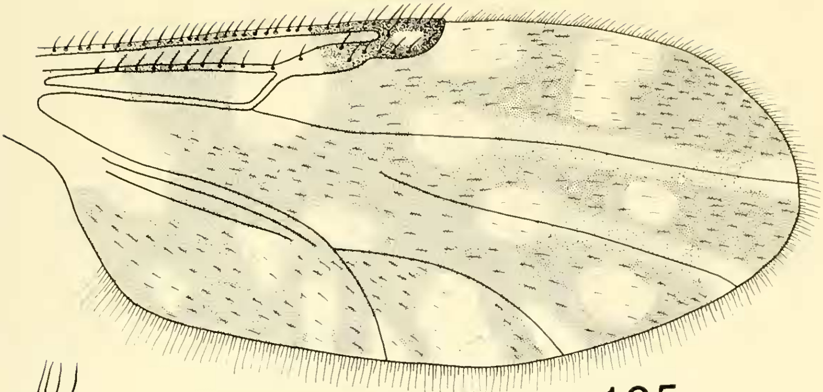
*Culicoides oklahomensis* Khalaf; Jones and Wirth, 1958, Jour. Kansas Ent. Soc. 31:82-85.

FEMALE—Length of wing 1.21 mm.

*Head:* Eyes narrowly separated, much less than diameter of a facet. Antenna with flagellomeres in proportion of 13:12:13:13:13:13:13:13:23:23:26:28:33, antennal ratio 1.29; distal sensory tufts present on segments 3, 5, 7, 9, 11-15; segments 9+10 to 11 in ratio of 0.82. Third palpal segment only slightly swollen (Fig. 106), 3.0 times as long as greatest breadth, with very shallow sensory pit. Ratio of length of head to proboscis 1.04. Mandible with 14 teeth.

*Thorax:* Fore and middle femora with broad, distinct pre-apical pale bands, hind femora with very faint pale pre-apical band, or band may be absent; all tibiae with subbasal pale bands, hind tibiae with large, distinctive pale bands. Hind tibial comb with 5 spines.

*Wing:* (Fig. 105). Second radial cell in a dark area; light spot on r-m crossvein large, extending from costa to slightly beyond vein $M_{1+2}$; poststigmatic spot small; an elongate mesally constricted spot in cell $R_5$; pale spots in cells $M_1$ and $M_2$ not attaining wing margin; pale spot in cell $M_4$ and distalmost spot in vannal cell attaining wing margin; pale spot on anterior surface of medio-cubital fork; pale spot crossing basal portion of vein $M_1$; pair of spots bordering vein $M_2$ slightly basad of its midlength; apices of veins



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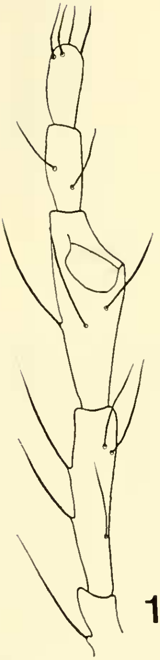

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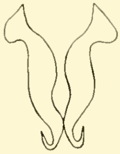

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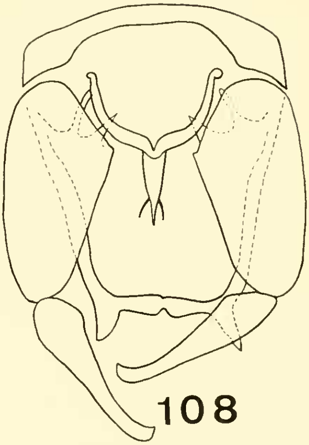

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FIGS. 105-108. *Culicoides oklahomensis* Khalaf. Female: 105, wing; 106, palpus. Male: 107, claspettes; 108, genitalia, claspettes removed.

$M_1$, $M_2$, $M_{3+4}$ and $Cu_1$ pale. Macrotrichia very abundant over entire surface of wing. Costa extending to 0.56 of distance to wing apex.

*Abdomen:* Two subequal spermathecae with very short ducts, 53 x 36 and 50 x 50 $\mu$; rudimentary spermatheca and ring present.

MALE—Genitalia (Figs. 107, 108) with ninth sternum narrow with very broad, deep caudomedian excavation. Ninth tergum tapering, with prominent blade-like apicolateral processes; median posterior portion distinctly notched. Basimere with simple, slender, well developed roots, dorsal root longer than ventral root. Telomere tapering to a slender, slightly curved, tipped point. Median posterior process of aedeagus broad basally, extending to very narrow, pointed apex, bearing a pair of subapical filaments; aedeagal arms slender and arcuate, with small, knobbed bases; basal arch notched mesally, extending to approximately half of overall length of aedeagus. Claspette with expanded basal foot containing tapered anterior process; stem very swollen, sinuate, abruptly narrowing to slender, unmodified recurved apex.

*DISTRIBUTION: Culicoides oklahomensis,* originally described as a subspecies of *villosipennis*, occurs in the southwestern part of the United States and in Mexico. Within the United States it has been reported from Oklahoma, Texas and Arizona. During this investigation *oklahomensis* was collected in Catron Co., New Mexico.

*DISCUSSION:* Males of this species can be separated from most others of the *guttipennis* group by the presence of lateral projections of the aedeagus. The only other species of the *guttipennis* group with such projections is the eastern *villosipennis* Root and Hoffman. The male genitalia of these two species can be distinguished by the shape of the claspettes. The females of *oklahomensis* can be recognized by the sensorial pattern, the large pale spot over the r-m crossvein and the pale border of vein $Cu_1$.

## *Culicoides palmerae* Group

This group, composed of *palmerae, utahensis,* and *novamexicanus,* has male genitalia characterized by very prominent apicolateral processes of the ninth tergum, strongly bent distal two-thirds of the telomere, broad aedeagus, and the well developed basal portions of the claspettes and roots of the basimeres. The females have a swollen third palpal segment, widely separated eyes, banding pattern on the legs very faint or absent and wings with dense macrotrichia.

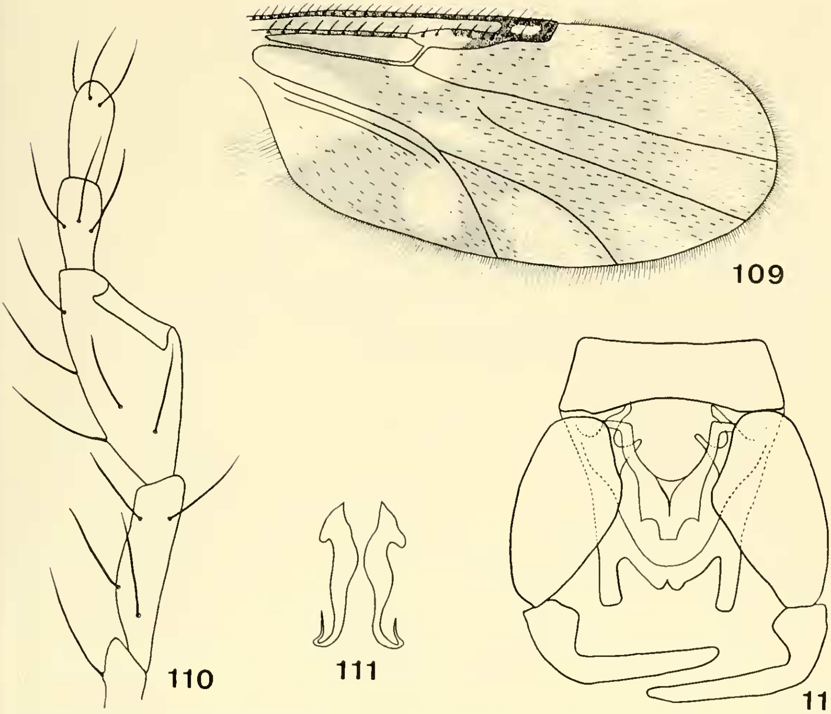
### 20. **Culicoides palmerae** James

(Figs. 109-112)

*Culicoides palmerae* James 1943, Pan-Pacific Ent. 19:151 (male, female; Colorado; fig. male genitalia).

FEMALE—Length of wing 1.48 (1.34-1.69; n=3) mm.

*Head:* Eye separation approximately equal to diameter of a facet. Antenna with flagellomeres in proportion of 12:9:9:9:10:10:11:12:18:18:22:23:33; antennal ratio 1.28 (1.18-1.43; n=3); distal sensory tufts on segments 3-15; segments 9+10 to 11 in ratio of 0.77 (0.75-0.78; n=2). Distal 4 palpal segments in proportion of 20:26:11:12; third palpal segment swollen (Fig. 110), 2.26 (2.07-2.45; n=3) times as long as greatest breadth, with broad, rather shallow sensory pore. Ratio of head length to proboscis 1.02 (0.89-1.15; n=4). Mandible with 14 teeth.



FIGS. 109-112. *Culicoides palmerae* James. Female: 109, wing; 110, palpus. Male: 111, claspettes; 112, genitalia, claspettes removed.

*Thorax:* Legs brown; knees dark; tibiae with faint subbasal pale rings. Hind tibial comb with 4 spines.

*Wing:* (Fig. 109). Wing pattern indistinct; second radial cell in a dark area; pale spot over r-m crossvein, extending slightly posterior of vein $M_{1+2}$; poststigmatic spot small; an elongate, rather indistinct pale spot in distal portion of cell $R_5$; indistinct pale spots in cells $M_1$, $M_2$, $M_4$ and vannal cell, all attaining wing margin; medio-cubital fork in dark area. Costa extending 0.56 (0.55-0.57; n=3) of total length of wing. Macrotrichia abundant over entire surface of wing.

*Abdomen:* Two elongate, subequal spermathecae 76 x 39 and 76 x 43 $\mu$; ducts not sclerotized; rudimentary spermatheca and ring present.

MALE—Description of male genitalia (Figs. 111, 112) based on male paratype from Ft. Collins, Colo. Ninth sternum with slight caudomedian excavation; membrane bare. Ninth tergum narrowing slightly posteriorly; posterior border very convex, with distinct mesal notch; apicolateral processes long, prominent, truncate. Basimere tapering distally; roots long, slender, subequal. Telomere strongly bent at approximate basal third, abruptly narrowed at bend, of more or less uniform width to apex. Aedeagus with median posterior process broad, with subapical lateral shoulders bearing posterior spines, apex truncate; adedeagal arms widely divergent basally, with prominent, laterally directed basal ends, arms slightly arcuate mesally, converging posteriorly; basal arch rounded, extending to about midlength of aedeagus. Claspettes with swollen bases; stems swollen basally, tapering posteriorly, apex strongly bent laterad then cephalad; apex with a few microscopic hairs.

*DISTRIBUTION: Culicoides palmerae* has previously been reported from the northwestern portions of the United States. Its range extends from Nebraska southwestward to California and northwestward to British Columbia. These first records from Sandoval and Taos counties in New Mexico constitute its southernmost known occurrence.

*DISCUSSION:* This species is very similar to *utahensis* Fox but may be separated from it by a moderately swollen third palpal segment with a broad pit. The wing pattern of *palmerae* is distinctly marked, as opposed to the poorly marked wing of *utahensis*. The presence of lateral shoulders on the aedeagus and slender claspettes will readily distinguish the males. For separation from *novamexicanus* n. sp., see discussion of that species.

### 21. **Culicoides utahensis** Fox

(Figs. 113-115)

*Culicoides utahensis* Fox, 1946, Ent. Soc. Wash. Proc. 48:246 (male; Utah; fig. male genitalia).

FEMALE*—Length of wing 1.43 mm.

*Head:* Eyes widely separated. Antenna with flagellomeres in proportion of 13:10:10:10:10:11:11:12:18:18:20:21:25; antennal ratio 1.12; distal sensory tufts present on segments 3-15; segments 9+10 to 11 in ratio of 0.75. Distal 4 palpal segments in proportion of 12:26:9:12; third palpal segment greatly swollen (Fig. 113), 1.85 times as long as greatest breadth, with deep sensory pit. Ratio of head length to proboscis 1.30. Mandible with 14 teeth.

*Thorax:* Legs dark brown. Hind tibial comb with 4 spines.

*Wing:* The following description is taken from Wirth (1952): "Wings grayish hyaline, anterior radial cells in a very dark spot, distinct light costal spots at r-m crossvein and at apex of second anterior radial cell, other light spots variable and indistinct, in well marked specimens with large light spots at tips of cells $R_5$, $M_1$, $M_2$, $M_4$ and anal cells, and large light areas at base of anal cell and in middle of wing between veins $M_{1+2}$ and $Cu_1$. Wings with abundant long yellowish macrotrichia over entire surface." Costa extending 0.55 of total length of wing.

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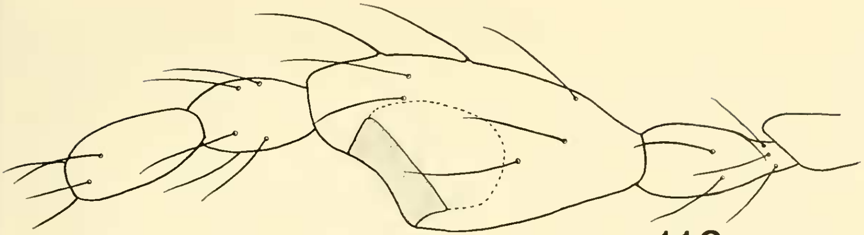
* No females of this species were collected during this study. The description was based on specimens collected from ears of rabbits at Battle Mountain, Nevada.



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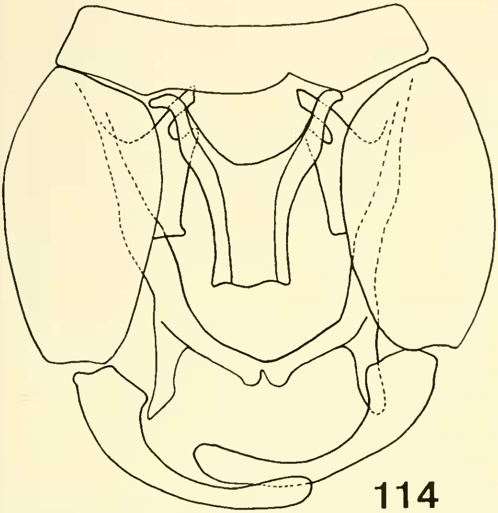

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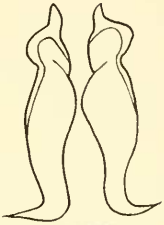

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FIGS. 113-115. *Culicoides utahensis* Fox. Female: 113, palpus. Male: 114, genitalia, claspettes removed; 115, claspettes.

*Abdomen:* Two subequal spermathecae 59 x 49 and 66 x 43 $\mu$; ducts sclerotized for a very short distance. Rudimentary spermatheca and ring present.

MALE—(Figs. 114, 115). Genitalia very large. Ninth sternum with slight caudomedian excavation, membrane bare. Ninth tergum only slightly tapering posteriorly; caudal portion convex, with prominent mesal notch; apicolateral processes long and distinct, of uniform width for most of length. Basimere rather short, slightly tapering posteriorly with large distinct mesal shelf on basal half, shelf more or less flat posteriorly; short ventral root and long, slender, mesally blunt dorsal root. Telomere swollen basally, sharply bent at basal third, apical two-thirds narrowed, approximately uniform width for remainder of length. Aedeagus very stout; median posterior process broad, truncate, with slightly sinuate apex; aedeagal arms short, with laterally directed bases; basal arch rounded, extending only about 0.35 of length of aedeagus. Expanded base of claspette with curved anterior process; stem strongly swollen basally, tapering to laterally turned, lancolate apex.

*DISTRIBUTION:* Previous records of *utahensis* indicate that it is limited to far western portions of the United States, having been reported from Utah, Nevada and California. The discovery of this species in the mountainous region of southern New Mexico (Lincoln Co., male) represents its easternmost record.

*DISCUSSION:* The high incidence of males with female head parts in this species has prompted considerable discussion. Downes (1958) discussed this phenomenon at some length and suggested the possibility of more than one species being included under the name *utahensis.* Both sexes of this species have been taken from the ears of jackrabbits on numerous occasions, and the males taken in this fashion have antennae and palps of the female type. This modification is assumed to assist the males in locating the host of the female and thereby facilitate mating. Copulation is probably initiated by contact. The modification of the head structures of the males of this species may represent evolution toward parasitism, instead of the predatory behavior exhibited by most other species of *Culicoides.*

So far as known all male representatives of this species from New Mexico have female head parts.

See discussion of *palmerae* and *novamexicanus* n. sp. for characteristics sufficient to distinguish these species.

### 22. **Culicoides novamexicanus** new species

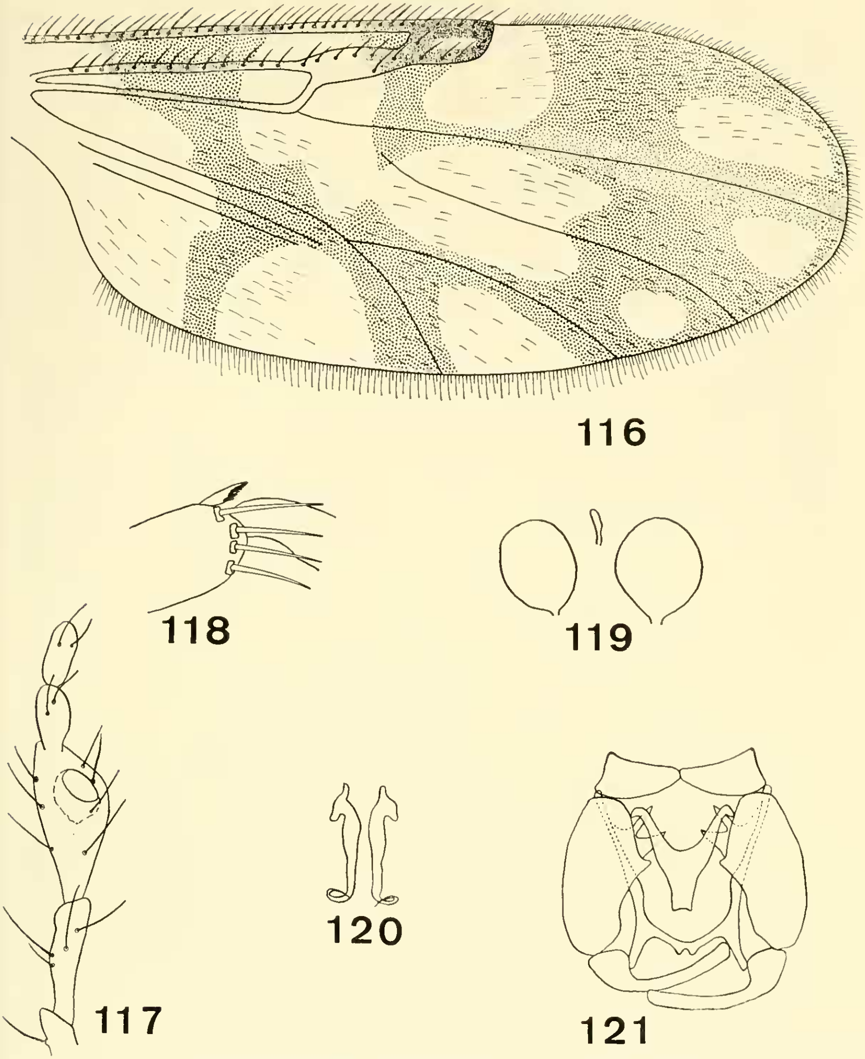
(Figs. 116-121)

FEMALE—Length of wing 1.23 (1.13-1.36; n=3) mm.

*Head:* Eyes separated about diameter of a facet. Antenna with flagellomeres in proportion of 13:10:10:10:10:10:11:12:15:16:18:18:25; antennal ratio 1.02 (0.98-1.05; n=3); distal sensory tufts on segments 3-5, 7, 9, 11, 13-15, occasionally absent on segment 4 or present on 6 or 12; segments 9+10 to 11 in ratio of 0.58 (0.55-0.60; n=3). Distal 4 palpal segments in proportion of 21:28:12:13; third palpal segment swollen (Fig. 114), 2.12 (2.0-2.2; n=3) times as long as greatest breadth; sensory pit moderately deep. Ratio of head length to proboscis 1.04 (1.01-1.06; n= 3). Mandible with 14-16 (n=3) teeth.

*Thorax:* Legs brown; tibiae with very faint, narrow subbasal pale rings. Hind tibial comb with 4 spines (Fig. 118).

*Wing:* (Fig. 116). Second radial cell in a dark area; poststigmatic spot large, bounded posteriorly by vein $M_1$; pale spot on r-m crossvein large, extending from anterior wing margin well beyond vein $M_{1+2}$, connecting with large pale area in proximal portions of cells $M_1$ and $M_2$; pale spot in cell $M_4$ and distalmost spot in vannal cell broadly joining wing margin; 2 large pale spots in proximal portions of cells $M_1$ and $M_2$ broadly encompassing basal half of vein $M_2$; basal portion of vannal cell and extreme basal area



Figs. 116-121. *Culicoides novamexicanus*, new species. Female: 116, wing; 117, palpus; 118, tibial comb; 119, spermathecae. Male: 120, claspettes; 121, genitalia, claspettes removed.

of cell $M_2$ in pale area; mediocubital fork in dark area; distal ends of veins $M_1$, $M_2$ $M_{3+4}$ and $Cu_1$ dark. Macrotrichia abundant over entire surface of wing. Costa extending 0.56 (0.55-0.57; $n=3$) of length of wing.

*Abdomen:* Two subequal spermathecae (Fig. 119) 69 x 46 and 56 x 43 $\mu$; ducts sclerotized for a very short distance; rudimentary spermatheca present. MALE—(Figs. 120, 121). Genitalia with ninth sternum divided; narrow, shallow, pointed caudomedian emargination. Ninth tergum tapering;

postero-medial portion convex, with prominent notch; apicolateral processes distinctly long and fingerlike. Basimere with dorsal and ventral roots subequal in size, without processes; dorsal root more slender than stout ventral root. Telomere swollen basally, abruptly bent and narrowed at approximately one-third of length from base, continuing at more or less uniform width to apex. Aedeagus stout; median posterior process conical, truncate; aedeagal arms strong, diverging anteriorly, basal portion of each turned posterolaterally to give footlike appearance; basal arch rounded, extending to approximately half length of aedeagus. Claspette with prominent foot-shaped base, with microscopic fringe of lateral spines on anterior "toe" portion; stem stout basally but tapering to slender, helical apex.

*DISTRIBUTION:* Chaves County, New Mexico.

*Specimens examined:* Holotype male. Pecos River, 7 mi. e. of Roswell, New Mexico, 14 June 1965, W. R. Atchley, at light. Allotype female and 3 female paratypes, same data.

*DISCUSSION: Culicoides novamexicanus* can be separated from *palmerae* by the sensorial pattern, smaller antennal ratio, lack of lateral projections on the aedeagus and the slender, simple claspettes; and from *utahensis* by the widely separated eyes, sensorial pattern, more extensive pale markings on the wings, the slender aedeagus and aedeagal arms and the characteristic claspettes.

## *Culicoides piliferus* Group

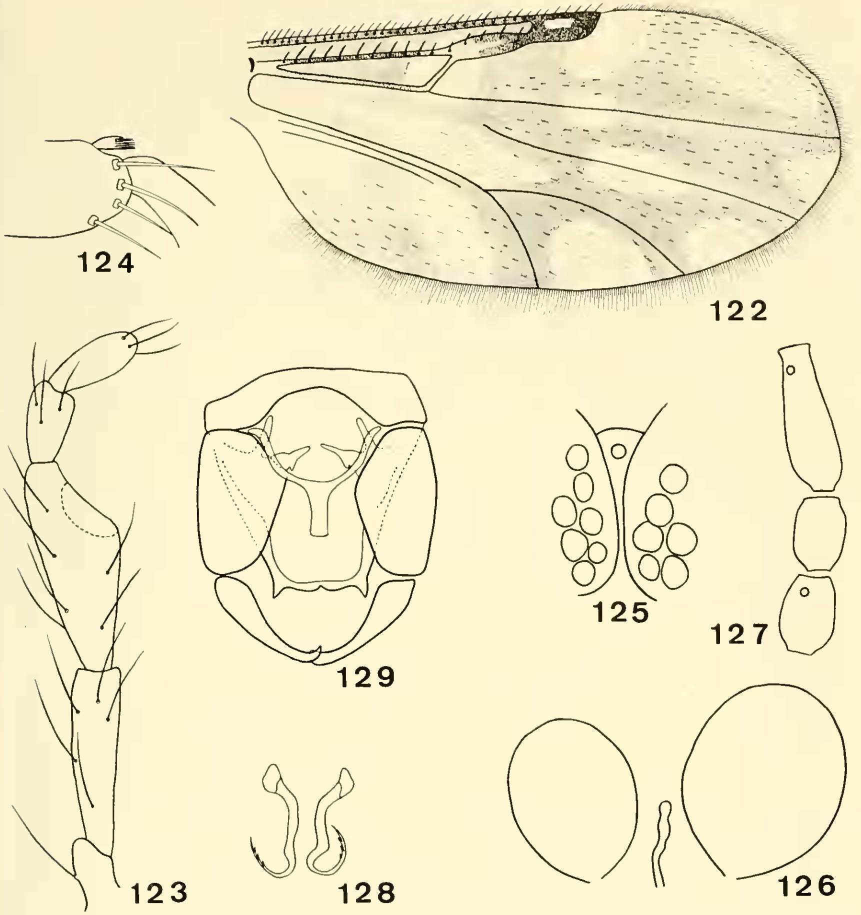
The wings of the females of the *piliferus* group usually have pale spots straddling the midportions of veins $M_1$ and $M_2$; however, the pattern is sometimes very reduced. The sensoria are found on segments 3, 5, 7, 9, 11-15 in the generalized condition, but may be reduced to the distal flagellomeres in some species. The eyes are contiguous to moderately separated and hind tibial comb possesses 4, occasionally 5, spines. The spermathecae are subequal to very unequal in size and usually lack necks. The ventral root of basimere is foot-shaped and the claspettes taper to a fine tip with a lateral fringe of spines.

### 23. **Culicoides doeringae** new species

(Figs. 122-129)

FEMALE—Length of wing 1.24 (1.13-1.34; n=14) mm.

*Head:* Eyes narrowly separated (Fig. 129); in holotype, separation approximately equal to width of median hair socket. Antenna with flagellomeres in proportion of 13:8:8:8:8:8:9:9:22:23:23:23:35; antennal ratio 1.63 (1.48-1.73; n=14), segments 9+10 to 11 in ratio of 1.11 (1.0-1.27; n=14) (Fig. 126); distal sensory tufts on segments 3, 5, 7, 9, 11, 13-15, occasionally also on 12. Distal 4 palpal segments in proportion of 22:23:10:9; third segment moderately broad (Fig. 123), 2.61 (2.3-2.87; n=12) times as long as



FIGS. 122-129. *Culicoides doeringae,* new species. Female: 122, wing; 123, palpus; 124, tbial comb; 125, spermathecae; 126, antennal segments 9-11; 127, interocular space. Male: 128. claspettes; 129, genitalia, claspettes removed.

greatest breadth, with shallow sensory pit. Ratio of head length to proboscis 1.12 (1.03-1.20; n=12). Mandible with 12-15 (n=12) teeth.

*Thorax:* Legs brown; fore and middle femora with pre-apical pale bands, all tibiae with subbasal pale bands. Hind tibial comb with 4 spines (Fig. 124).

*Wing:* (Fig. 122). Second radial cell in a dark area; small round spot over r-m crossvein barely extending beyond vein $M_{1+2}$; poststigmatic spot small; pale spot in distal portion of cell $R_5$; pale spots in distal portions of cells $M_1$, $M_2$ and $M_4$ all attaining wing margin; spot in distal portion of vannal cell variable, usually large, round anteriorly, mesally constricted in many specimens, with posterior portion either expanded or, as in holotype, extended to wing margin in same width as mesal constriction; pale spot on vein $M_1$ immediately behind poststigmatic spot; pale spot near mid-length of vein $M_2$; a rather elongate pale area bounded posteriorly by mediocubital fork extending anteriorly almost to veins $M_{1+2}$ and $M_2$. Costa extending 0.58 (0.56-0.59; n=14) of wing length. Macrotrichia abundant over entire surface of wing.

*Abdomen:* Two very unequal spermathecae (Fig. 125) 76 x 56 and 56 x 39 μ, ducts unsclerotized; rudimentary spermatheca and ring present.

MALE—Genitalia (Figs. 128, 129) with ninth sternum possessing deep caudomedian excavation. Ninth tergum with small, triangular apicolateral processes, mesal notch distinct. Basimere tapering slightly; ventral root triangular, with definite "heel-like" process on mesal margin; dorsal root long, slender. Telomere with swollen base, narrowing distally to mesally tipped apex. Aedeagus with long, parallel-sided, truncate median posterior process; aedeagal arms slightly knobbed basally, arcuate mesally; basal arch gently rounded, extending approximately 0.45 length of aedeagus. Claspettes distinctly knobbed basally; stems sinuate, gradually diminishing toward tip, with a fringe of apical spines.

*DISTRIBUTION:* New Mexico (Catron, Lincoln and Otero Counties) and Arizona.

*Specimens examined:* Holotype female, Catron Co., Glenwood Fish Hatchery, 2 Aug. 1965, W. R. Atchley, at light. Allotype male, Lincoln Co., Alto Reservoir, 16 June 1965, W. R. Atchley, at light. Paratypes: 18 females, same data as holotype; 1 male, 2 females, same data as allotype; 4 males, 9 females, Lincoln Co., Ruidoso, Cedar Creek Canyon, 16 June 1965, W. R. Atchley, at light; 5 females, Otero Co., Silver Creek Canyon, 28 July 1965, W. R. Atchley, at light. Additional specimens examined: 2 females, Coconino Co., Oak Creek Canyon, Arizona, 22 July 1959, C. W. O'Brien; 1 female, Cochise Co., Southwest Research Station, Arizona, 1 Aug. 1964, D. R. Davis; 1 female, Cochise Co., Chiricahua Mts., 2 mi. n. of Paradise, Arizona, 6 July 1964, D. R. Davis.

*DISCUSSION: Culicoides doeringae* belongs to the *piliferus* group and is probably most closely related to the eastern *piliferus* Root and Hoffman. These two species may be differentiated by the slightly smaller antennal ratio, the greater ratio of antennal segments 9+10 to 11 and the sensoria pattern 3, 5, 7, 9, 11, 13-15 in *doeringae*.

Atchley and Wirth (1967) have given characters sufficient to distinguish *doeringae* from *riggsi* Khalaf, another southwestern species of the *piliferus* group.

It gives me great pleasure to name this species for Dr. Kathleen C. Doering, Professor Emerita of insect morphology at the University of Kansas.

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# ERRATUM

In the paper by F. J. Rohlf and R. R. Sokal, "Coefficients of correlation and distance in numerical taxonomy," *University of Kansas Science Bulletin,* vol. XLV, No. 1, pp. 3 to 27, Figures 9 and 10 were inadvertently interchanged. Thus Figure 9 is above the legend of Figure 10, while Figure 10 appears above the legend for Figure 9.

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